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THE VALUE OF ROENTGEN-RAY THERAPY IN PRIMARY MALIGNANT TUMORS AND BENIGN GIANT CELL TUMOR OF BONE*

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IN August, 1920, Codman[1] of Boston began, for and in the interest of the family of a patient, whom he was treating for a supposed bone sarcoma, an investigation "to ascertain the actual facts as to whether there were any living cured cases of this disease, and if there actually were, to ascertain the methods of treatment by which these patients had been cured." A circular letter was sent to all members of the American College of Surgeons, and later to other individual surgeons and physicians, who became interested in the problem, asking them to report all living cases of bone sarcoma, with special reference to the treatment applied. This, at first merely private correspondence, soon evolved into the organization of a Registry under the guidance of the American College of Surgeons, including all cases of bone tumors, living or dead, and comprehending such a wealth of material as never before experienced in the history of bone tumors.

As a first step in the study of this most instructive material, a committee was formed with the scope of establishing a uniform nomenclature and a new classification. It became apparent at once that the many clinical, pathological and roentgenological terms suggested in the literature were only confusing and without much practical value. Furthermore, it appeared evident, as Codman says, "that by-products were to be the result of the industry of the Registry rather than the intended product of obtaining the answers to the simple questions." A uniform nomenclature and a new standard classification were such by-products, for they meant the first step toward the acquisition of knowledge of bone tumors.

NOMENCLATURE AND CLASSIFICATION OF BONE TUMORS

The nomenclature and classification accepted by the Registry Committee embraces all varieties of bone tumors and is as follows:

1. Metastatic tumors, originating from tumors or other tissues than bone.

2. Periosteal fibrosarcoma. Clinically

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these are tumors which lie next to the bone, originating in the outer layers of the periosteum or in the adjacent fascia or tendinous insertions, but which do not invade the bone, although they may cause absorption by pressure on the adjacent surface of the bone. Histologically they show no tendency to form osteoid tissue, cartilage or bone.

3. Osteogenic tumors. These are tumors which are believed to be derived from cells thought to be the common ancestors of the cells which form bone, cartilage, the fibrous network of bone and the tissue formerly called myxomatous. They may be (*a*) benign, and (*b*) malignant.

(*a*) Benign osteogenic tumors. This group includes fibroma, myxoma (many authors consider this type of tumor essentially malignant) and osteochondroma (including osteoma, chondroma, fibro-osteoma, fibrochondroma, fibromyxochondroma, fibromyxo-osteochondroma, myxochondro-osteoma, etc.).

(*b*) Malignant osteogenic tumors. These are the true osteogenic sarcomata. The old nomenclature according to the preponderance of the different component parts,—fibrous, myxomatous, cartilaginous or bony (the so-called osteosarcoma, chondrosarcoma, myxochondrosarcoma-osteomyxofibrosarcoma, fibromyxochondro-osteosarcoma, etc.) has been abandoned. However, certain anatomic varieties such as (A) periosteal, (B) subperiosteal and medullary, (C) telangiectatic, and (D) sclerosing, are maintained.

4. Inflammatory conditions. This also includes osteitis fibrosa and such conditions as Paget's disease, von Recklinhausen's disease, and the various forms of single and diffuse cystic diseases of the bone.

5. Benign giant cell tumor.

6. Angioma, angiosarcoma. Exceedingly rare.

7. Ewing's tumor.

8. Myeloma.

A special heading is reserved for the so-called borderline cases.

Though the above classification includes all forms and varieties of bone tumors, the main purpose of the registry was and still is to study the primary malignant bone tumors. In order of the frequency of their occurrence, the primary malignant bone tumors may be arranged in the following groups:

1. Osteogenic sarcoma.
2. Ewing's tumor.
3. Myeloma.
4. Periosteal fibrosarcoma.
5. Borderline cases.

Certain types of benign tumors showing at times a malignant clinical appearance such as myxoma, multiple enchondroma, etc., are also included in this group.

"Five Year Cures" Recorded in the Registry

There is a unanimity of opinion of all investigators that the "five year cures" in the treatment of primary malignant bone tumors belong to the rarest occurrences. In 1922, Codman,[1] after analyzing 452 cases of the Registry, wrote: "We know of only four cases of true bone (osteogenic) sarcoma which are alive in this country today, who were treated over five years ago. These were all treated by amputation alone. No other proved cases are known to be alive who have recovered under any other form of treatment. These four cases are those of Bloodgood and Follis, Hubbard, Wells and Rixford. There are a few others under dispute, but we are not quite satisfied with the evidence. Even in these four cases, the *x*-rays have not been presented." Later this number has somewhat increased, so that in 1926, Codman[2] was able to report 17 cases (13 cases of osteogenic sarcoma and 4 cases of Ewing's tumor) of "five year cures." "But also in these cases," as Codman writes, "much essential evidence is lacking. In ten of these, for instance, the *x*-ray has been lost. The evidence on few of the seventeen is entirely convincing. As to the treatment all but one of the seventeen had amputation, and that one had a local exploration followed by intensive radium treatment and mixed toxins. Nine of the other sixteen also had toxins. Eight also had radiation. In eight cases, these treatments were combined. Seven had no other treatment than amputation." In other words, all cases cured were treated either

by amputation alone, or by amputation and toxins or by amputation, toxins and radiation, but there is not one case treated by radiation alone, not even by amputation and radiation, without toxins, combined. Similar opinions were expressed by a number of other investigators. Thus Eising[3] says: "The Roentgen ray and radium are of a very questionable benefit, our sole resort is amputation at the earliest moment." Again, Bloodgood[1] says: "My experience up to date seems to show that x-ray and radium therapy cannot be expected to affect the pathological process through a bone shell; moreover, when radiation therapy is used, it is employed largely for conditions in which it is neither necessary nor valuable." Coley[5] directly condemns radiation therapy as producing more harm than good. He writes in an article in 1924: "Up to the present time, we have no evidence to prove that a single, central malignant sarcoma of the long bones or a single periosteal osteogenic sarcoma has been cured by radium or x-ray alone, or even combined with curettage. Hence it would seem unwise to continue for any length of time radium or x-ray treatment with the possibility of metastases developing during such treatment." MacGuire and McWhorter[6] write: "Our series of osteogenic and giant-cell tumors show no evidence of benefit from the Roentgen ray or radium therapy, even where it has been applied in the depths of the bone cavity." And the list of such statements could be long continued, for there are many of them.

There is only one explanation why radiation therapy, in general, and roentgen-ray therapy, in particular, has been almost unanimously condemned as a therapeutic agent in the treatment of a condition where other methods, strongly advocated, have given equally, if not more, ungratifying results: Radiation therapy was until recently in the experimental stage, and the doses administered were too small to produce any appreciable therapeutic effect. Since the introduction of the highly penetrating radiation with larger, well-measured and more scientifically applied doses, however, radiation therapy, especially in the form of deep roentgen-ray therapy, is becoming more and more prominent in the treatment of the malignant bone lesions. Codman,[2] appreciating this, says: "We are confident that each year in the future the report of the Registrar will be more favorable—particularly in regard to the use of radiation." Kolodny,[7] who recently in reviewing the entire material of the Registry of Bone Sarcoma, wrote a most brilliant monograph on the primary malignant tumors of the bone, says, with regard to radiation therapy: "Thus radiation is as disappointing as radical surgery, but the difference in the sacrifice the patient has to make for radiation as compared with radical surgery is enough to justify the former procedure, especially since it is still in the experimental stage, when the last word has not as yet been spoken. When we learn more about the biology of radiation and acquire the same skill in administering radiation therapy as we possess in using the scalpel, we may hope for far better results from radiation."

Five years have now elapsed since our first cases of bone tumors were treated by deep roengen-ray therapy. On the basis of the results obtained, therefore, we propose in this article to prove that the roentgen ray used alone, or in combination with other methods, is one of the most powerful therapeutic agents at our disposal in the treatment of malignant primary bone tumors. The treatment of benign giant cell tumors is also included here. All cases reported are registered with the Registry of Bone Sarcoma of the American College of Surgeons, and the diagnosis is that of the Registry Committee.

GENERAL PRINCIPLES OF ROENTGEN-RAY THERAPY

In studying the response of the different types of bone tumors to irradiation, we cannot escape the impression that the basic factor is the primary influence of the roentgen rays upon the tumor tissues. This necessitates a consideration of the morphologic structure of the tumor in the first instance.

Since bone is a tissue most peculiar in structure, it is only natural that the tumors originating from such a tissue should be

of an equally complex construction. Indeed, not less than four tissue elements (fibrous, myxomatous, cartilaginous and osseous) are represented in the composition of the majority of bone tumors. These tissue elements show a great variety of radiosensitiveness. It is of natural consequence, therefore, that all bone tumors should behave in their response toward radiation as highly complex systems of interdependent structures rather than simple aggregates of cells. In other words, it is necessary that aside from the cellular structure, we consider also other factors, such as intercellular structure, and especially the blood supply of the tumor tissues.

As regards the "cellular structure" of the bone tumors, we find that the Registry Committee discourages the use of the words "cell" and "tissue." Thus the Registrar writes: "We believe that clinical surgeons will be less confused if pathologists will drop the use of 'cell' terms and 'tissue' terms in their laboratory reports. Prognosis cannot be based or treatment formulated on diagnosis of 'round cell sarcoma' or on the differences between 'chondrosarcoma,' 'myxosarcoma,' 'fibromyxochondro-osteosarcoma,' or any of their possible wordy combinations." While it is true that such "cellular" differentiations as "small-round-cell sarcoma," "spindle-cell sarcoma," "mixed-cell sarcoma," etc., or such "tissue" differentiations as "chondrosarcoma," "osteochondrosarcoma," "fibromyxochondro-osteosarcoma," etc., are of little value from the point of view of prognosis or treatment to be formulated, on the other hand, it cannot be denied that the degree of differentiation of the "cells" or "tissues" is a most important criterion from the point of view of the roentgen-ray therapy to be applied. The well-established law of Bergonié and Tribondeau holds good also for bone tumors, thus: first, the more embryonal and undifferentiated the type of the tumor cell, the greater its radiosensitiveness; second, dividing (mitotic) cells are eight to fifteen times more vulnerable than when in a resting condition, and, third, hyperchromatic cells are more readily destroyed than the cells poor in chromatin.

Not less important, from the standpoint of radiosensitiveness of the tumor, is the amount of the intercellular substance. Bone tumors, as a rule, consist of fibrous, cartilaginous, osseous and myxomatous substances. The proportion of these, and especially their relationship to the cellular elements, determines the fate of that particular tumor when exposed to radiation. Very cellular tumors with scanty intercellular substance eventually entirely disappear under irradiation, while tumors rich in fibrous or myxomatous paraplastic structures respond more slowly, and osseous and cartilaginous tumors often remain entirely refractory to irradiation.

Still another factor influencing the radiosensitivity of the various bone tumors is their blood supply. The endothelium of young blood vessels is more sensitive to radiation than that of well-formed adult blood vessels. Moreover, the presence of many blood vessels within a tumor as a rule indicates an increased metabolic rate, leading to the production of many rapidly growing, highly undifferentiated, morphologically and histologically atypical cell elements. It follows, therefore, that the richer a tumor in blood supply, the greater its radiosensitivity, and vice versa.

The consideration of the above factors in the estimation of the value of roentgen-ray therapy in bone tumors is of fundamental importance. We thoroughly agree with the Registry Committee, that a clinical and roentgenological diagnosis should be attempted in the first instance in all cases of bone tumors, and that an exploratory incision be reserved as a last resort; but, a biopsy once done, we do not think that the "cell" or "tissue" terms should be dropped from the reports. However, the stress should be laid on the degree of differentiation of the cells rather than on their morphological structure. The amount of the intercellular substance and the abundance of the blood supply should also be stated.

In formulating such a conception of the problem, we may establish the following more or less general rules with regard to the radiosensitiveness of the different bone tumors:

1. Cellular tumors without much stroma

Fig. 1. Case 1. Osteogenic sarcoma of the right ilium. Bone destruction forms the principal part of the lesion.

Fig. 2. Same as Figure 1. Following intensive roentgen-ray therapy, the new bone formation became the predominating feature of the disease. The tumor now shows marked sclerosis.

and rich in blood supply, though from the clinical and surgical viewpoint very malignant, may entirely disappear following irradiation.

2. Tumors of the adult type, especially when rich in mature intercellular structures (cartilage and bone) and poor in blood vessels, may prove entirely refractory to irradiation, while surgical procedures may lead to excellent results.

3. In tumors of the intermediate type, the more undifferentiated cells may be made to disappear, and the growth of the more adult cells may be retarded by irradiation, so that they produce an abundance of calcific (cartilaginous and osseous) intercellular substance. In such instances, the type of the tumor may entirely change under the influence of radiation.

Two cases are briefly presented to illustrate this selective action of the roentgen ray on the various tumor elements.

Case 1. *Registry No. 526. Mr. F. S., aged sixty-three.*

Onset of the disease indefinite. When first seen in 1920, a history of pain of seven years' duration was given.

Examination in April, 1920, revealed a tumor mass in the right pelvis apparently attached to the right ilium.

At operation, April 10, 1920, a tumor mass 3 × 3 in. was shelled off the ilium, and curetted. Within one year, there was recurrence.

Examination made in April, 1921, revealed a recurrent tumor mass in the region of the right ilium. Roentgenograms of the pelvis (Fig. 1) showed slight changes in the structure of the right ilium. There was evidence of bone destruction and some new bone formation, the bone destruction predominating. At a second operation, April 28, 1921, the tumor was separated with some difficulty from the outer surface of the crest of the ilium. A second portion of the tumor was found penetrating in toward the spinal column through the deep muscles of the back and between the curves of the sacral nerve trunk. This portion was shelled out easily. The bony attachment was curetted and cauterized.

Pathological Report. Very rapidly growing spindle cell sarcoma (Fig. 3).

Following the second operation, the patient received several superficial roentgen-ray treatments. Subsequent to Aug. 8, 1922, he received two series of deep roentgen-ray therapy.

On Nov. 30, 1923, the patient expired. A few days previous to his death, roentgenograms of the pelvis were obtained (Fig. 3). Comparison with the previous roentgenograms revealed a marked change in the type of lesion. While originally the bone destruction formed the preponderating part of the lesion, at this time new bone formation became the predominating feature, and the tumor appeared to be entirely replaced by a mass of bony material. This was confirmed by the microscopic examination made following the autopsy, which revealed a chondro-osteosarcoma (Fig. 4).

Summary. This case represents an osteogenic sarcoma which, at the beginning, clinically, roentgenologically and patholog-

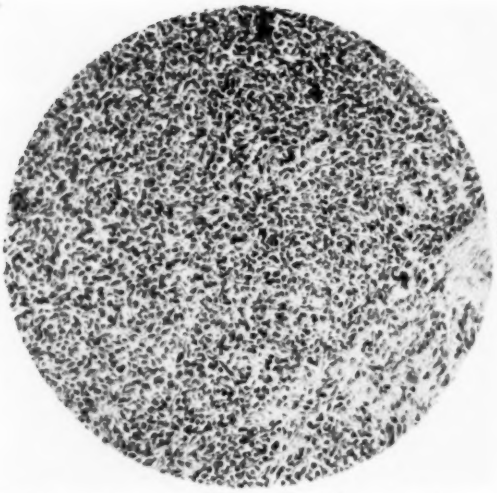


Fig. 3. The histologic section in case of Figure 1 shows small spindle cell variety of osteogenic sarcoma.

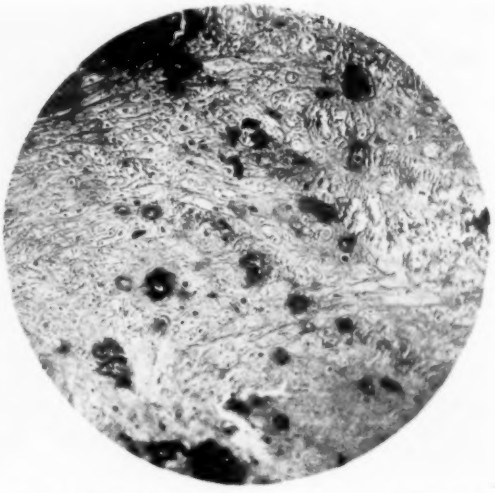


Fig. 4. The histologic section in case of Figure 2 shows chondroos-teosarcoma variety. The tumor consists in its greatest part of atypical cartilage with hyalinization and marked sclerosis.

ically, was of the rapidly growing, very malignant "cellular" type, but which following the administration of radiation therapy, was transformed into a slow-growing "sclerosing" osteochondrosarcoma.

Case II. *Mr. W. W., aged forty-three. (Case not classified by the Registry.)*

Fig. 5. Case II. Tumor of the right temporal bone (roentgenologic diagnosis—osteogenic sarcoma) producing marked swelling of the right temporal region.

Fig. 6. Same as Figure 5. Roentgenogram shows evidence of bone destruction and new bone formation.

History. Onset of disease unknown. Patient first admitted to Harper Hospital on Nov. 13, 1914, with a history of protrusion of the right eye for about two years. Dr. Donnelly, on examination, found that the right eye was more prominent than the left. "One feels a hard, cartilaginous body in the outer periorbital tissue, which seems to be attached to the outer

Fig. 7. Same as Figure 5. Five years following roentgen-ray therapy. The swelling has entirely disappeared.

and upper border of the orbital orifice. It slips from under one's finger. The eye can be propelled forward and it seems as if one could force the eye out on the cheek. The patient says he has no symptoms whatever. He thinks that the right eye is the better. Externally both eyes appear normal except for the prominence of the right eye."

Operative Findings (Nov. 13, 1914). Removal of cyst in external portion of right orbit. Zygoma chiseled through for exposure of cyst, external to periorbital tissue, but in orbit.

No microscopic examination was made of the tissue removed.

In 1917, a growth appeared at the outer canthus of the right eye. The right eye was removed, the lesion entirely cleaned and a plastic operation performed. Erysipelas followed shortly after which lasted for a period of five weeks, followed by good healing.

The microscopic report at this time was epithelioma.

The patient was symptom-free until 1921, when there was considerable pain in the right temporal region. At the same time a slight swelling appeared, which slowly enlarged. In 1923, the pain became more severe and on Nov. 20, 1923, the patient presented himself at our department.

Findings Nov. 20, 1923. Examination revealed absence of the right eye, with a

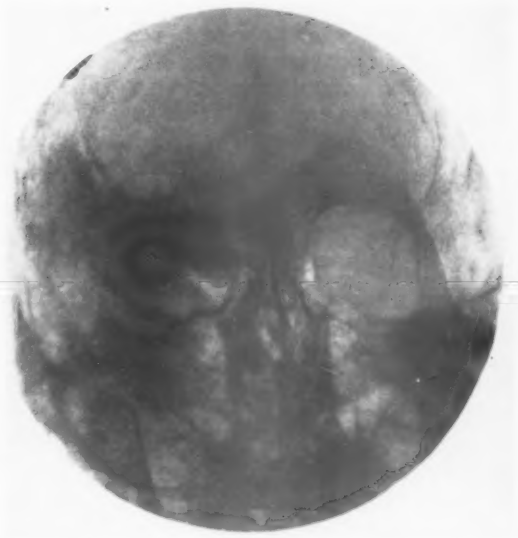


Fig. 8. Same as Figure 5. Roentgenogram shows increased sclerosis in place of former lesion.

plastic operation in the region of the right orbit. Marked swelling in the region of the right temple, which does not have the appearance of being inflammatory. Patient complains of marked pain in this region, of a dull aching character. Photograph taken (Fig. 5). Stereoscopic roentgen-ray examination of the skull revealed evidence of a pathological process in the region of the right temple, extending into the sphenoid and supraorbital plates, consisting of bone destruction and new bone formation (Fig. 6). The appearance is that of an osteogenic sarcoma. We did not believe this lesion had any connection with the former one, but was a distinct entity. The general condition of the patient was uninfluenced by the lesion.

Nov. 2, 1923, First Deep Roentgen Therapy. A dose of 90 per cent S.U.D. was given. Quality of roentgen rays: 0.13– Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters.

Dec. 29 and 30, 1923, Second Deep Roentgen Therapy; 110 per cent S.U.D. given. Quality of roentgen rays, same.

Following the second deep roentgen therapy, there was marked improvement in the condition of the patient, and he became entirely symptomless. For this reason, he did not return for observation until July 4, 1925.

Findings, July 4, 1925. The swelling has practically disappeared.

June 1–, 1928. The swelling has entirely disappeared (Fig. 7). Stereoscopic roentgen examination of the skull reveals definite increased bone density involving the left portion of the sphenoid. The process has extended into the supraorbital plates on the

right side, and extends up along the greater and lesser wings of the sphenoid to the parietal and temporal bones, where there is considerably more bone production at this time than observed before treatment was given (Fig. 8). Apparently the process is checked. The general condition of the patient is excellent, and he is entirely free from symptoms.

Summary. Though the history of this case is somewhat confused, and the diagnosis rests upon the clinical and roentgenological aspects, no biopsy having been made, nevertheless it appears certain that the tumor which slowly but gradually continued to increase in size for a period of two years, promptly receded following irradiation, producing at the same time a disappearance of all the clinical symptoms. The roentgenological aspect of the tumor changed from that of a combination of bone destruction and new bone formation in the beginning, to one of very slow bone sclerosis, lasting now over a period of five years.

Comparison of this response to irradiation of bone tumors with other methods of treatment, especially with that of mixed toxins which is accredited by the Registry with "nearly as many cures as all the surgeons of the country together,"[2] reveals a peculiar coincidence in the similarity of the results. Thus, Coley and Coley[8] say: "The mixed toxins of erysipelas and bacillus prodigiosus alone have effected a cure in certain numbers of cases, but all of these cases have been of the round cell or spindle cell type, characterized by little production of new bone. The mixed toxins and radium combined have likewise resulted in the complete disappearance and apparent cure of an even larger number of cases of a similar type, but neither toxins nor radium singly or combined have effected a cure in any case associated with marked new bone production." It would be interesting to know, therefore, whether or not a combination of deep roentgen-ray therapy and mixed toxins would result in an increase in the number of cures obtained with either method alone. Theoretically, at least, such an increase should exist.

It would also be interesting to know whether or not the administration of colloidal lead or other heavy metals in combination with deep roentgen-ray therapy would improve the results already obtained.

In the cases enumerated in this article, deep roentgen-ray therapy alone was used (except for the cases of osteogenic sarcomata of long bones where a combination of deep roentgen-ray therapy with radical surgery is advised). Therefore, these cases furnish an uncompromising proof of the value of roentgen-ray therapy in primary malignant bone tumors.

1. OSTEOGENIC SARCOMA

The osteogenic sarcoma, or true bone sarcoma, is the most malignant of all bone tumors. The Registry, after an untiring search for several years was able to collect only 13 cases of osteogenic sarcoma which may be considered as "five year cures," and some of these are open to question.

In reviewing the medical literature, we find several statistical reports giving a higher percentage of permanent cures, but it is probable that such reports include other lesions than the true osteogenic sarcoma. This is clearly demonstrated in a Communication from Greenough, Simmons and Harmer,[9] who, on examination of cases of bone sarcoma admitted to Massachusetts General and the Collis P. Huntington Memorial hospitals from 1911 to 1921, wrote: "Of 148 cases sent in as possible bone sarcoma, only 68 could be considered to be cases of malignant new growth of bony origin, the remaining 82 cases proving, on more detailed study, to be metastatic tumors of bone (29 cases), sarcoma primary in the soft parts (28 cases), inflammatory conditions (11 cases), or tumors of a non-sarcomatous type (14 cases)." But perhaps the most interesting, and at the same time the most tragic fact, is that the case of Codman's,[2] in whose interest the Registry of Bone Sarcoma was started, believed to be bone sarcoma, proved at autopsy to be a metastatic carcinoma of unknown origin. It is not surprising, therefore, that, because of insufficient knowledge and because of the confusing nomenclature which existed before the organization of the Registry, conditions more benign were often classed

as osteogenic sarcoma, and thus the percentage of the "five year cures" erroneously increased. The Registry has the distinct merit of having brought out these errors in a manner which suffers no contradiction. As a result, as Codman points out:[2] "We can only say that it is probable that an occasional case of osteogenic sarcoma may be saved by amputation or by amputation combined with toxins and radium; that in one atypical case of primary malignant bone tumor with metastasis in the groin, the patient recovered after an exploratory operation and the postoperative use of Coley toxins and radium."

The question arises: Is roentgen-ray therapy able to change this rather hopeless situation?

The roentgen-ray therapy of osteogenic sarcoma and the success obtained therefrom depends on factors which influence the structural arrangement of these tumors. On the one hand, we have the aggressive expansion of the tumor elements and, on the other, there is the natural tendency of the normal bone to build up defensive protective measures against the continuous aggression of the tumor. The expansion results in bone destruction and the more rapid the expansion, the greater the bone destruction. The self defense of the normal bone is evidenced by a periosteal reaction of new bone formation, and the greater the defense ability, the greater the amount of new bone produced. Very rapidly expanding osteogenic sarcomata with considerable bone destruction are, as a rule, tumors rich in undifferentiated cellular elements showing marked vascularity with little or no paraplastic intercellular structures. Osteogenic sarcomata provoking marked protective measures of the normal bone with considerable formation of new bone are slowly growing; consequently, the tumor elements reach a high degree of differentiation and the regressive changes often predominate. While the first may show remarkable response toward roentgen-ray therapy, the latter are more recalcitrant and often an inhibition of the expansive capacity with increase of the defensive protective measures and consecutive production of regressive changes is all that can be hoped for.

There is, however, another factor of fundamental importance which must be considered in the roentgen-ray therapy of osteogenic sarcomata. This, while dependent upon the dosage applied, is closely connected with the peculiar structure and composition of the normal bone tissue itself. Ewing,[10] who made a detailed study of this problem, describes it as follows: "Experience in the treatment of bone sarcoma shows that the normal bone resists all but very heavy radiation, but begins to show damage when high voltage roentgen rays are used for five or six hours. These doses generally produce much growth restraint, with ossification necrosis, and hemorrhage in sarcoma tissue. The danger in this procedure is the incitement of a chronic productive radiation osteitis. In this condition, the bone becomes very hard and brittle, spontaneous fractures often occurring; the periosteum becomes thickened and hyaline points and flakes of necrotic bone appear, and the shaft may be greatly increased in thickness. Meantime, the bone marrow is deprived of marrow cells and is reduced to an ill-nourished mass of mucinous fat and fibrous tissue. I have the impression that under the above dosage the whole exposed shaft may become practically dead, although functioning, and that about it a new involucrum must eventually form if the bone is to be restored."

Dosage. In taking into consideration the above factors, we must establish for the treatment of osteogenic sarcoma a dose which, while highly damaging to the more undifferentiated embryonal type cell elements, must not injure the normal bone tissue elements. Such a procedure in the rapidly growing "cellular" osteogenic sarcomata, in which bone destruction forms the predominating part of the disease, often produces entire disappearance of the lesion, resulting in permanent cure. In the highly differentiated types of tumors in which the intercellular material is abundant and the regressive changes predominate, the process remains of a limited "growth restraint" value, and a more or less pronounced sclerosis is all that can be accomplished. In such instances, the combination of roentgen-ray therapy with

radical surgical measures should be, and in our estimation is, of distinct value.

The dose which, although destructive to the highly sensitive cellular elements, is within the safe limits of the normal bone tissue, corresponds to 90 to 100 per cent skin unit dose (600–650 R in air). Such a dose may be repeated at intervals of from six to eight weeks. If the osteogenic sarcoma is of such clinical and histologic appearance that a good therapeutic result may be expected, as in Case III, the dose may be increased to 110 to 120 per cent S.U.D., but if growth restraint with alleviation of the symptoms is all that can be hoped for, the dose should be decreased with each subsequent treatment so that no damage to the normal bone tissues results.

Of course, death in the osteogenic sarcoma results from metastases, which, as a rule, appear very early, and which practically always occur in the lung tissues. Therefore, in order to insure a more or less permanent result, our attention from the beginning must be directed toward this metastatic process. It is advisable to consider that every case of osteogenic sarcoma has metastasized to the lungs, and treat it as such. In a few instances, metastases may occur to other parenchymal organs or to the skeleton, but even in such cases, the dissemination is the result of the arterious transportation from the lungs. In rare cases, metastases to the adjacent lymph nodes through invasion of the lymphatic system may develop. The dosage used for combating the metastatic process is the same as that used for the primary lesion. Even in case of prophylactic irradiation of the lungs, it is best to administer the full dose.

Method of Procedure. Our procedure is as follows: First, a diagnosis of osteogenic sarcoma is established by the clinical and roentgenological methods, without exploratory incision. History, onset, duration, rapidity of growth, clinical appearance, roentgenological aspect—especially as regards the type and extent of bone destruction or new bone formation, and the amount of intercellular deposits—are all data which should be considered in making a diagnosis. If no accurate diagnosis can be made, it is safer to make a tentative diagnosis and treat uncertain or borderline cases as true osteogenic sarcomata, rather than to resort to an exploratory incision.

From the standpoint of roentgen-ray therapy, we may divide osteogenic sarcomata into two distinct groups: (1) the osteogenic sarcomata of the flat bones (pelvis, spine and skull), which, because of their topographic location are usually inoperable, and (2) the osteogenic sarcomata of long bones, where operative procedures may advantageously be combined with irradiation.

(1) In the osteogenic sarcomata of flat bones, roentgen-ray therapy is our sole method of treatment—except, perhaps, for the use of mixed toxins. An operation in such cases would be incomplete, and since an eradication of the primary tumor could not be accomplished, it should not be attempted. Roentgen-ray therapy, in these cases, often leads to truly remarkable results. Because of the difference in structure of the flat bones, and more especially because of the various expanding conditions of tumors originating from these bones, osteogenic sarcomata of the flat bones are generally of the "cellular, vascular" type. Hence the response to irradiation is often pronounced, and "cures" may be obtained in cases in which invasion of the lungs has already occurred. The following case will illustrate this point:

Case III. *Registry No. 523. Mrs. H. B., aged thirty-five.*

Onset. In 1920, the patient developed pain in the left thigh and hip joint producing a "grinding sensation," more severe at night. For six months, she was bedridden for about three days each week; considerable loss in weight. For the last three weeks, the pain had been so intense that the patient could not sleep.

Examination on Jan. 20, 1921 (before operation). There is a large tumor mass in the left iliac region, apparently attached to the inner side of the left ilium. The mass extends medianward to the middle of the abdomen, and downward as it enters the pelvis. On palpation, the mass feels hard and there is marked tenderness on palpation over the crest of the left ilium.

Operative Findings, Jan. 29, 1921. Incision

FIG. 9. Case III. Osteogenic sarcoma of the left ilium. "Cellular," bone destructive type.

FIG. 10. Same as Figure 9, six years following roentgen-ray therapy. Lesion healed. Complete bone regeneration.

over the mass occupying the inner surface of the crest of the ilium. The mass fluctuates—giving the impression of fluid or abscess. On opening sac, a considerable amount of broken-down, sarcomatous tissue escaped. Incision enlarged and cyst found to extend into free abdominal cavity, closely adherent along the inner surface of the ilium so that removal was impossible.

On Feb. 3, 1921, 75 mg. of radium was inserted in the sarcoma sac for thirty-two hours. Following this, a course of superficial roentgen-ray treatments was given, using the old technique.

Pathological report. Very malignant small spindle cell sarcoma (Figs. 11 and 12).

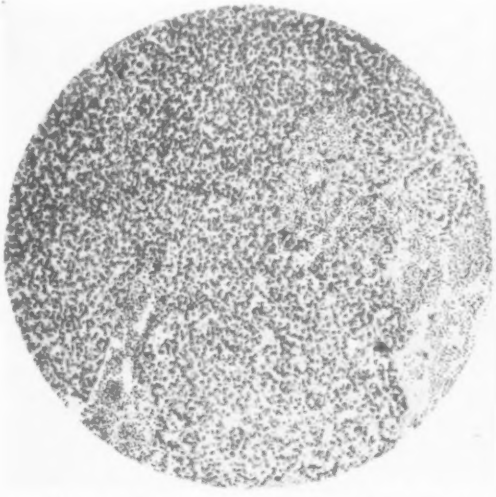


FIG. 11. Histologic section of Case III, showing "cellular" type of osteogenic sarcoma.

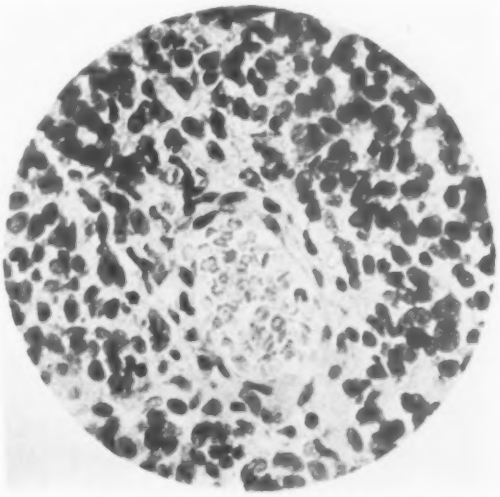


FIG. 12. Same as Figure 11. High power.

Following the radium treatment, combined with a series of superficial roentgen-ray treatments, there was marked improvement. This lasted for a period of a year. The lesion then recurred, and the condition of the patient became worse.

May 23, 1922. Patient was referred for deep roentgen-ray therapy.

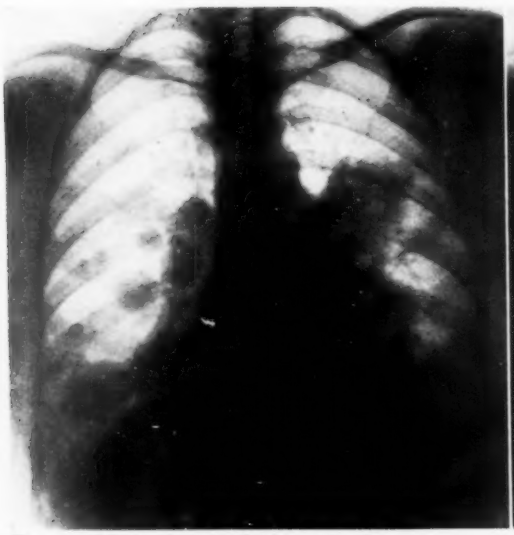


Fig. 13. Metastases to the lungs in Case III.

Fig. 14. Same as Figure 13, almost six years following roentgen-ray therapy. Normal appearance of the chest.

Findings, May 23, 1922. There is a mass in the region of the left pelvis, apparently attached to the left ilium. It appears, from the examination, that the mass is a recurrence of the sarcoma. Roentgenograms of the pelvis show an area of bone destruction of the left ilium corresponding to the tumor mass. There is no evidence of new bone formation (Fig. 9). Roentgenograms of the chest are negative for evidence of metastasis to the lungs.

Diagnosis. Osteogenic sarcoma of the left ilium, cellular, bone destructive type.

Treatment. Massive roentgen-ray therapy over pelvis, cross-fired for the tumor mass and left ilium (110 to 120 per cent S.U.D.).

May 22 and 23, 1922. First series of roentgen-ray therapy given. Dose: 120 per cent S.U.D. (775 R in air). Quality of roentgen rays, 0.137Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters, air-cooled tube, 4 ma.

Findings July 18, 1922. There is marked improvement in the condition of the patient. The pain has entirely disappeared, and the patient has gained about 10 pounds in weight. The tumor mass is reduced in size, but has not entirely disappeared.

July 18, 1922. Second series of deep roentgen-ray therapy given over the pelvis. Dose and method of application the same. Following the second series of treatments, there was further improvement in the condition of the patient. This lasted for a period of four months. Then a dry hacking cough developed. She was again seen in our department on Dec. 27, 1922.

Findings, Dec. 27, 1922. The patient complains of a very severe cough and marked dyspnea. For the last four weeks, she has lost rapidly in weight and her condition is extremely poor. Stereoscopic roentgenograms of the pelvis show complete regeneration of the bone at the site of the former tumor, and no tumor mass is palpable in the abdomen. Stereoscopic roentgenograms of the chest, however, show very extensive metastases to both lungs. Some of the metastatic areas are 10 cm. in diameter (Fig. 13). It is evident that the rapid deterioration in the condition of the patient is due to the development of metastases to the lungs. At this time, deep roentgen-ray treatment was directed over both lung fields and over the pelvis.

Treatment. 110 per cent S.U.D. over both lungs and left pelvis.

On Dec. 27, 1922, a third series of roentgen-ray therapy was given over the pelvis, and a first series over both lungs (the detailed technique of the roentgen-ray therapy of neoplastic pulmonary metastases is described elsewhere[11]).

Following this treatment, there was a marked reaction for a period of three weeks. Intensive nausea, high temperature, very pronounced cough, entire loss of appetite, and still further weakening, causing further increase in the already severe symptomatology of the patient, but stereoscopic roentgen-ray examination of the chest three weeks after the treatment showed that the lung fields have practically cleared up and from this time on, the patient's condition improved rapidly.

Stereoscopic roentgenograms of the chest taken three months after the treatment showed

evidence of some infiltration of the lung fields near the root of the lung, resembling that of central pneumonia, due to the irradiation.

Stereoscopic roentgenograms of the chest six months after treatment showed that the infiltration around the root of the lung had disappeared and the lungs were normal in appearance.

Findings on June 24, 1928. Patient is enjoying good health. Roentgenograms of the pelvis (Fig. 10), as well as those of the chest (Fig. 14), show normal conditions.

Summary. This case represents an osteogenic sarcoma of the left ilium with metastases to the lungs. Date of onset, 1920. Jan. 29, 1921, incision for diagnosis, excision impossible. Feb. 3, 1921, radium inserted in tumor, followed by a course of superficial roentgen-ray treatments, using the old technique, with marked improvement. One year later, recurrence of tumor mass and symptoms. In May and July, 1922, two series of deep roentgen-ray therapy produced marked improvement. In December, 1922, metastases developed to the lungs. Dec. 27, 1922, a third series of deep roentgen-ray treatments over the lungs and pelvis produced permanent healing.

(2) In the osteogenic sarcomata of long bones, there is, from the onset, a combination of several tissue elements. Only those which, in their differentiation, do not proceed further than the myxomatous stage are amenable to irradiation. The cartilaginous and osseous tissues remain entirely refractory to irradiation. Therefore, a combination of radical surgery with radiation therapy will lead to best results in such instances.

Since the degree of malignancy in these tumors is governed by the undifferentiated elements, and since these elements show the greatest radiosensitiveness, it seems only logical that the treatment of every osteogenic sarcoma of the long bones should be started by a preliminary irradiation. This seems indicated in view of the fact that radical surgery alone has so little to offer.

As Kolodny[7] says: "At first glance, it is strange that, although the experience of radical surgery has been disappointing, it has until recently dominated all therapeutic considerations in bone sarcoma." Even now, one hears repeatedly and with great persistency, the claim that every operable bone sarcoma should be operated upon immediately and "no time should be wasted" with preliminary irradiation. Only the inoperable cases are left for the roentgen therapist.

It is our conviction that much can be gained by the preliminary irradiation of every bone sarcoma for this reason: It is an established fact that the time of appearance of the lung metastases is dependent on the cellular structure of the primary tumor. The more cellular the primary tumor and the more undifferentiated the cells composing the tumor, the sooner the lung metastases will appear. In the sclerosing type of osteogenic sarcomata, metastases to the lungs do not occur until late. A preliminary irradiation therefore would have a tendency to lessen the probability of metastases by destroying the highly radiosensitive cell elements of the tumor. If, on the other hand, at the time of irradiation, lung metastases already existed, a radical operation at this time would have remained without any appreciable influence on the ultimate outcome of the disease. In both cases, nothing has been lost by the preliminary radiation therapy.

Our method of procedure is as follows: A preliminary series of roentgen-ray treatments is first given over the primary lesion. This is followed in four to six weeks by radical surgery. Then, within eight to fourteen days following the operation, prophylactic irradiation over the lungs is instituted.

The following case is presented because from the time of the diagnosis and first radiation therapy to the time of radical operation—due to other methods of treatment—so much time had elapsed that a metastatic process to the lungs should have developed. In our estimation, the roentgen-ray therapy is responsible for the fact that this did not occur.

This case also disproves the contention that an immediate radical operation is more essential than the "waste of time" required for preliminary irradiation. A year elapsed between the application of

Fig. 15. Case IV. Osteogenic sarcoma of the upper end of the right fibula, showing distortion of the contour of the leg due to the tumor mass.

Fig. 16. Same as Figure 15. Following roentgen-ray therapy and resection of the upper end of the fibula, there was recurrence.

the first series of roentgen-ray therapy in this case and the radical operation, and no metastases to the lungs developed.

Case IV. *Registry No. 889. Mr. P. M., aged twenty-five.*

Onset of disease in January, 1923, with pain in the upper part of the right leg and slowly developing swelling of the outer aspect of the upper third of the right leg.

In July, 1923, a local operation was performed, but no report of the findings could be secured. In September, 1923, the patient consulted Dr. Blodgett, who, on examination, found a swelling of the upper third of the right leg with a decided tenderness at the point of swelling. There was no change in the sensation or motor control. A diagnosis of possible osteogenic sarcoma was made. From October, 1923, to January, 1924, the patient consulted other physicians.

Feb. 7, 1924. At this time, examination revealed that the swelling had increased in size. Roentgen-ray studies showed the possibility of an osteogenic sarcoma. Wassermann reaction negative. Patient received potassium iodide and salvarsan without result.

In February, 1924, patient was referred to our department for radiation therapy, with a diagnosis of possible osteogenic sarcoma of the upper part of the right fibula.

Findings, Feb. 7, 1924. There is marked swelling of the upper portion of the right leg, the swelling being confined principally to the anterolateral aspect of the leg. On palpation, there is apparently a tumor mass connected with the right fibula. The tumor is hard and somewhat sensitive to manipulation (Fig. 15).

Roentgen-ray examination at this time shows a process of the upper portion of the right fibula consisting of bone destruction and bone regeneration. There is periosteal new bone formation. The appearance is that of an osteogenic sarcoma (Fig. 17). Roentgenograms of the chest were negative for evidence of metastases.

Feb. 7–8, 1924. First series of deep roentgen therapy. Treatment was given over the site of the primary lesion, the entire upper two-thirds of the right leg being included within the treated zone.

Technique. 110 per cent S.U.D. over the diseased area (715 R in air). Quality of roentgen rays 0.13 Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters, air-cooled tube, 4 ma.

March 24, 1924. At this time the condition was about the same as previously. There was no reduction in the size of the tumor. Roentgen studies of the upper two-thirds of the right leg, however, showed that the process had improved. There was more new bone formation, with increased sclerosis of the bone structures of the fibula.

March 24–25, 1924. Second deep roentgen treatment. The same technique used.

April 1, 1924. Operation with removal of about 5 inches of the upper portion of the fibula, together with the tumor mass.

Microscopic findings. (2155–24 Grace Hospital.) Osteogenic sarcoma (Fig. 18).

Dec. 30, 1924. Patient returned to our

A B

FIG. 17. Same as Figure 15. Roentgenogram showing typical picture of osteogenic sarcoma.

department, stating that following the operation he felt better. However, he was not able to step on his leg except with difficulty. In October, 1924, there was recurrence of the lesion.

Examination Dec. 30, 1924. There is a recurrent fungating mass on the outer aspect of the right leg at the site of the original tumor. The mass is about 6 cm. in diameter, has broken through the skin, and protrudes about 4 cm. (Fig. 16). At this time there was enlargement of the inguinal lymph nodes. This, however, seemed to be inflammatory in origin. Roentgen studies of the chest were negative for evidence of metastases to the lungs.

Dec. 30, 1924. Third series of deep roentgen-ray treatments.

Jan. 6, 1925. Amputation of right leg in the mid-thigh region. Patient made an uneventful recovery and was soon able to return to work.

June 30, 1928. Condition of the patient is good. There is no evidence of recurrence or metastases. Patient is working at his usual occupation.

Summary. This is a case of osteogenic sarcoma of the upper end of the right fibula. Onset of disease January, 1923. Two series of deep roentgen-ray treatments were given, after which resection of the upper end of the fibula was performed. Recurrence. After a third series of deep roentgen-ray therapy and amputation, healing occurred.

Under the heading of osteogenic sarcoma should be included a type of tumor which clinically has all the characteristics of bone malignancy, but which, from a

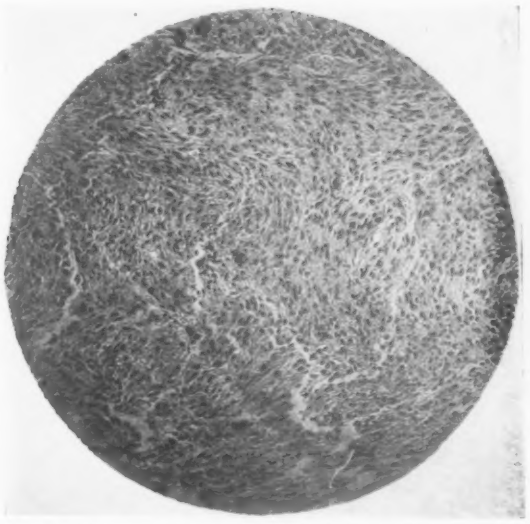


FIG. 18. Same as Figure 15. Histologic section showing small spindle cell variety of osteogenic sarcoma.

pathological standpoint, is not definitely classified as yet. These tumors, if left alone, grow very rapidly, the course of the disease being that of osteogenic sarcoma. However, they show ready response to irradiation, and permanent healing is not infrequent. Several such cases were treated in our department during the past six years, with invariably good results.

The following is an illustrative case:

CASE V. *Registry No. 524. Mr. L. A., aged thirteen.*

In June, 1921, patient first noticed swelling of the right cheek, which gradually increased in size. There was considerable pain, more pronounced at night. Later the swelling extended to the roof of the mouth, and the right nostril became completely obliterated. In June, 1922, a piece of tissue was removed for biopsy. Following the exploratory incision, repeated nose bleedings occurred, some of them very severe. Toward the end of 1922, the tumor grew to such an extent that the patient began to have difficulty in talking and swallowing.

Findings, Feb. 16, 1923. There is a swelling of the right cheek due to a tumor mass of the right superior maxilla (Fig. 19). There is prominence of the hard palate, as well as of the soft palate, on the right side, indicating that the tumor is rather extensive and of an aggressive character.

Roentgen-ray studies showed a marked destruction of the right superior maxilla with clouding of the right antrum. There is some thickening of the lateral nasal wall with

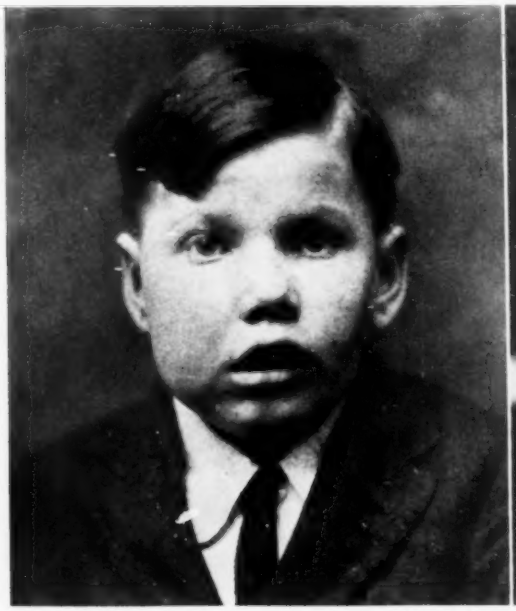


FIG. 19. Case v. Osteogenic sarcoma of the right superior maxilla, producing marked distortion of the contour of the face.

FIG. 20. Same as Figure 19, five and a half years following roentgen-ray therapy. Lesion clinically healed.

destruction of the nasal septum. The appearance from the roentgenological examination is that of an osteogenic sarcoma (Fig. 21). The general condition of the patient is rather poor. There has been considerable loss of weight and rather pronounced anemia.

Diagnosis. Osteogenic sarcoma of the right superior maxilla.

Treatment. Deep roentgen-ray therapy combined with radium application.

FIG. 21. Same as Figure 19. Roentgenogram shows destruction of the right superior maxilla, with clouding of the right antrum.

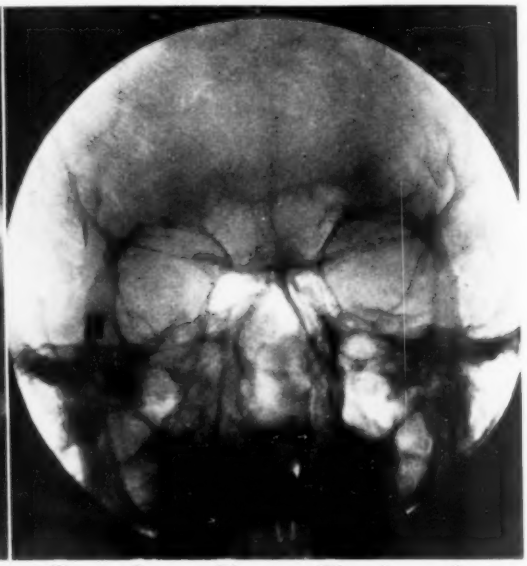


FIG. 22. Same as Figure 20. There is complete regeneration of the bone.

Feb. 15–17, 1923. Deep roentgen-ray therapy given. Quality of roentgen rays 0.137 Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters; dose, 90 per cent S.U.D. over

right superior maxilla, cross-firing through three portals of entry; air-cooled tube, 4 ma.

In addition to this, 55 mg. radium (screened by 1 mm. brass and 1 mm. hard rubber) was placed in the right nostril for a period of three hours.

Shortly following the treatment, the condition of the patient started to improve and within a period of one year, the lesion entirely healed.

June 30, 1928. There is a normal condition present (Fig. 20). Roentgenograms show practically complete regeneration of the right superior maxilla (Fig. 22).

Summary. This case represents a tumor of the right superior maxilla which was enlarging very rapidly in size, and which roentgenologically showed all the characteristics of osteogenic sarcoma. Following the administration of roentgen-ray therapy, combined with local application of radium, there was complete healing of the lesion.

The pathological classification of this lesion is not well established as yet. The following are the remarks of Ewing with regard to this case: "This case seems to belong to a group which has been appearing at the Memorial Hospital for many years and which I have been unable to classify. Repeated sections of tissue show much new growth of vascular connective tissue, with infiltration by lymphocytes but never any areas of undoubted sarcoma. I suspect that they represent a specific disease which is essentially inflammatory and connected with chronic infectious osteitis. I am not prepared to deny that some of them and the one here registered is not a malignant neoplasm, but I think that on the evidence, it should for the present be classified as inflammatory."

Codman says: "I believe this tumor belongs to the group to which Ewing refers, and of which we have examples in the Registry collection. Nevertheless, a remarkable case."

Other pathologists classify the condition as true osteogenic sarcoma. We believe, therefore, that until the question is definitely settled, we have to content ourselves with the clinical and roentgenological classification of the disease, and these both indicate a highly malignant process.

2. EWING'S TUMOR

Connor,[12] in reviewing all cases of bone tumors recorded in the Registry, was able to collect 67 cases of Ewing's tumor, or about 10 per cent of the total registered. Based on the study of such a large collection, Connor establishes the following factors as the main characteristics of Ewing's tumor, or endothelial myeloma: "Their almost constant location in the shafts of the long bones and in flat bones where osteogenic sarcoma seldom occurs, their peculiar morphology, the type of cell being easily distinguished from the osteoblast in most cases, and their susceptibility to radium and roentgen ray treatment."

Since radiosensitiveness forms one of the chief characteristics of Ewing's tumor, it follows that irradiation, and more especially, roentgen-ray therapy should be applied in the first instance in the treatment of this condition. It is true that operation (local or radical) was performed on some cases, leading to a permanent cure, but this, as a rule, was combined with other methods of treatment, such as radium, roentgen rays or mixed toxins. Since Ewing's tumor, from the earliest stages, is a multiple lesion, it is probable that the second factor in the combination played a rôle at least as important as the operative procedure. More recently, because of the improved technique, roentgen-ray therapy seems to have entirely replaced all other therapeutic measures.

The reason for the production by irradiation of such prompt disappearance of Ewing's tumor is to be sought in the peculiar morphological structure of the lesion. Ewing's tumor is a rapidly expanding, sometimes infiltrating, sometimes mechanically pressing, but always bone-destroying sarcoma. The type of cell is round, oval, or polyhedral, with abundant mitotic figures, and showing a peculiar perithelial or perivascular arrangement. There is almost complete absence of intercellular structures, the only supporting stroma consisting of thin bands of connective tissue, occasionally dividing the more or less diffuse tumor into smaller lobules. In the angio-endothelioma type,

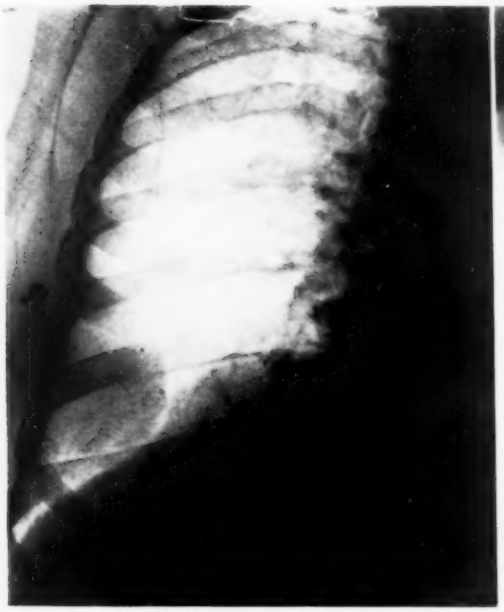


Fig. 23. Case VI. Ewing's tumor. Large tumor of the right lower lung with partial destruction of several ribs.

Fig. 24. Same as Figure 23. Following roentgen-ray therapy, the tumor has entirely disappeared.

there is, in addition, a rich vascularity of the tumor. In all instances, the rapidly growing, primitive, highly undifferentiated cells produce neither cartilage nor bone nor collagen, and they lead to a diffuse absorption of the involved bone. It is readily recognized that all of these features are factors which, from the point of radiosensitivity, make a tumor an ideal medium for roentgen-ray therapy.

There is another indication for irradiation in cases of Ewing's tumor. The rapidly growing cells in their limitless expansion invade the blood and lymph stream, thus producing metastases through both channels in the earliest stage of the disease. Indeed, many authors, among them Ewing,[13] consider endothelial myeloma from the beginning a multiple lesion similar to myeloma. However, the fact remains that metastases occur very early and these metastases or multiple tumors can be controlled only by extensive irradiation. Of course, we realize that in a great majority of cases, the disease when first recognized, is already so generalized that treatment becomes of only palliative value, but until some other method is found, radiation remains our most important therapeutic agent.

The dosage and method of procedure are the same as for osteogenic sarcoma, except perhaps for the fact that special attention is to be paid to the multiplicity of the lesion. The results obtained are, both with regard to immediate effect and life expectancy, better than in osteogenic sarcoma. Connor[12] found that of the collected cases, one patient is alive fifteen years, one lived nine years (this patient dying from an accident) and 15 are living four years after the onset of the disease. Codman[2] states that 4 of these patients passed the "five year" period. Considering the rarity of Ewing's tumor as compared with osteogenic sarcoma, these figures represent a much higher percentage of "cures."

Case VI. *Registry No.* 888, *Mr. W. D. T., aged fifty-six.*

In 1924, the patient first noticed a tumor in the region of the lateral lower chest on the right side. This tumor was growing gradually in size, and probably represents the primary tumor. A second tumor appeared in 1925, on the head, and a third tumor in 1926 in the right shoulder. These tumors were also growing at about the same rate as the primary lesion.

March 24, 1927. Patient, for the first time, came to Harper Hospital for treatment.

Findings, March 24, 1927. The tumor in the region of the right lower chest, which is

FIG. 25. Same case as in Figure 23, showing large tumor of the skull, with marked destruction of the tables of the skull.

FIG. 26. Same as Figure 25, showing gradual bone filling following roentgen-ray therapy.

described as the primary lesion, is the size of the fist. Roentgen-ray examination of the chest shows that the tumor has caused destruction of the fifth, sixth, seventh, eighth, ninth and tenth ribs on the right side. The tumor protrudes into the lung, producing a mass 8 cm. in diameter (Fig. 23).

The second tumor observed was that on the skull. Roentgenograms of the skull show that the tumor causes complete destruction of the parietal bones corresponding to the vertex (Fig. 25). The tumor mass protrudes over the hairy scalp and is the size of two fists. The maximum point of protrusion is about 10 cm. above the normal line of the vertex. There are no brain symptoms in connection with the tumor.

The third tumor observed in the region of the right shoulder is the size of a hen's egg. Roentgenograms of the shoulder girdle show that the tumor has produced a destructive area in the clavicle involving the distal half of the shaft of the clavicle, as well as the base of the acromial and coracoid processes of the scapula.

In addition, roentgen-ray studies were made of both the upper and lower extremities, including all bony structures, and there is evidence of a similar destructive process in the shaft of the middle third of the left tibia.

Roentgenograms of the entire spine and pelvis were negative for evidence of bony changes except for extensive arthritic changes involving the lumbar vertebrae.

Blood Count. Hemoglobin, 90 per cent; red blood cells, 3,150,000; white blood cells, 5,200. Polymorphonuclears 58 per cent, lymphocytes 37 per cent, mononuclears 5 per cent, morphology normal.

Blood chemistry normal.

Urine examination shows evidence of albumin, but is negative for evidence of Bence-Jones protein.

General condition of the patient remained uninfluenced by the lesions. There has been no loss of weight, and the patient is entirely symptomless. The tumor has never produced any pain. The patient is a stout, well-developed, well-nourished individual.

Diagnosis. Ewing's tumor.

March 24–30, 1927. Deep roentgen-ray therapy was given over the pathological areas. Dose: 90 per cent S.U.D. (600 R in air). Quality of roentgen rays 0.137 Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters, water-cooled tube, 25 ma.

Oct. 14, 1927. Second deep roentgen-ray therapy over the mass in the sternum (same technique).

Nov. 10, 1927. Third deep roentgen-ray therapy over all pathological areas (same technique).

June 27, 1928. All masses have disappeared. Roentgenograms of the pathological areas (Figs. 24 and 26) still reveal evidence of bone destruction. However, there is increase in lime density which indicates probable bone regeneration. The destructive areas were so large that complete bone regeneration will be impossible in places, and of long duration in others.

General condition of the patient is satisfactory.

Summary. This case represents a typical Ewing's tumor, with multiple lesions in the shafts of the long bones, the ribs, the skull and the lungs. Following the extensive application of roentgen-ray therapy, all lesions promptly disappeared.

FIG. 27. Case VII. Endothelioma of hard palate. There is bone destruction of the left half of the hard palate.

FIG. 28. Same as Figure 27, showing complete bone regeneration following roentgen-ray therapy.

We should like to include here another case which represents an entirely different type of tumor, although histologically it is classed as endothelioma.

Ewing[13] distinguishes three forms of endothelial tumors: (1) angioendothelioma; (2) solitary diffuse endothelioma, and (3) multiple endothelial myeloma (Ewing's tumor). There is some dispute between pathologists with regard to the advisability of placing such a variety of tumors under the same common group of "endothelioma," especially since very little is known with regard to the histogenesis of the three varieties forming the group. Kolodny,[14] for example, thinks that the endothelial myeloma, or Ewing's tumor, should be entirely separated from the two other varieties, since "the course, the clinical incidence, the prognosis and the morphology are entirely different in Ewing's tumor from what they are in those grouped by Ewing under the first two headings," and since "there is no sufficient proof on hand to support the contention of Ewing that 'diffuse endothelioma' (Ewing's tumor) is really an endothelioma." Without entering into the analysis of this discussion, we have recorded the above facts merely as an explanation of the divergence of opinion among pathologists with regard to the histological classification of the following case.

From our standpoint, it is sufficient that the process was declared a very malignant one and that it was generally recognized that the irradiation produced a good therapeutic effect.

CASE VII. *Mrs. C. H., aged forty-four. (Case not definitely classified by the Registry.)*

Onset of disease unknown. Patient states that in 1919 following the grippe, she noticed for the first time a small tumor on the roof of the mouth. This was not painful, but it slowly increased in size, until in 1925, it occupied the entire roof of the mouth. In April, 1925, she came for the first time to the Cancer Clinic at Harper Hospital for examination. The patient also complained of a tumor mass in the lower abdomen, producing symptoms of distention. Since 1918, the menstrual periods had been irregular. Since November, 1924, no periods had been present. There was some vaginal discharge for a period of two years. No loss of weight.

Findings April 20, 1925. There is a tumor of the roof of the mouth occupying practically the entire left half of the roof of the mouth and producing an elevation of about 1½ inches in its center. The mass is rounded, with a smooth surface. There is no ulceration of the mucous membrane of the roof of the mouth. On palpation, the mass is firm, and apparently connected with the bony structures.

Roentgenograms of the roof of the mouth show evidence of bone destruction corresponding to the left half of the hard palate (Fig. 27). This is also evidenced on the films made in the anteroposterior position.

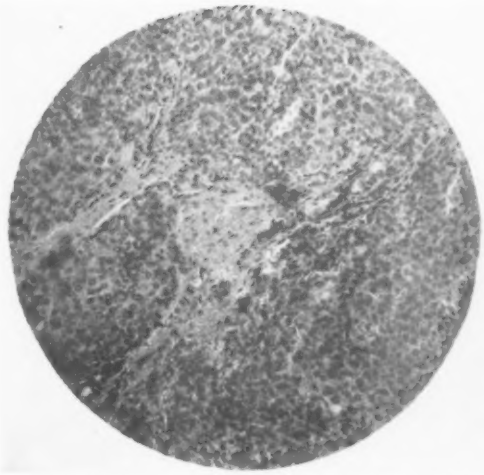


Fig. 29. Histologic section of Case VII in Figure 27. "Cellular" tumor. Endothelioma, also classified as undifferentiated round cell sarcoma.

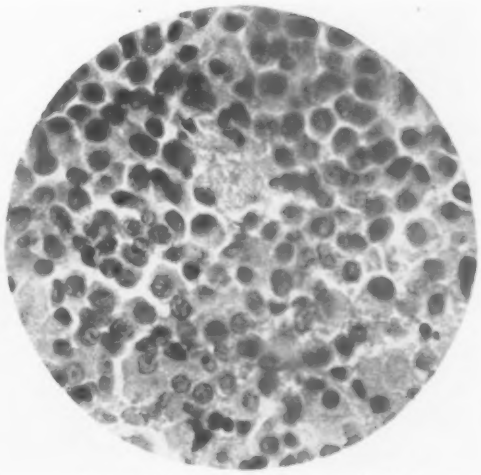


Fig. 30. Same as Figure 29. High Power.

There is also evidence of large uterine fibroids, with bilateral pus tubes.

Method of Treatment. Patient was advised to have radiation therapy over the tumor of the roof of the mouth, which was to be followed six weeks later by a curettement of the tumor, and later with deep roentgen-ray therapy, and radium treatments, depending on the microscopic findings.

The uterine fibroids were to be treated by radiation therapy alone.

On April 20, 1925, 55 mg. of radium, screened by 1 mm. brass and 1 mm. hard rubber, was placed against tumor of roof of mouth for three hours.

April 22–24, 1925. First deep roentgen-ray therapy cross-fired for tumor of the hard palate. Total dose, 110 per cent S.U.D., 720 R in air; quality of roentgen rays, 0.137 Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al as filters.

May 1, 1925. First deep roentgen therapy for uterine fibroids (exovulation dose).

June 14, 1925. Patient re-admitted to Harper Hospital for curettement of the mass. There was marked reduction in the size of the tumor following the first series of radiation therapy.

June 19, 1925. Mass removed. Substance soft, cheesy in quality. Old mass curetted. Silver nitrate to base, and patient returned to ward in good condition.

Microscopic Findings (Dr. P. F. Morse). Endothelioma with cylindromatous changes and peculiar pigmented areas (Figs. 29 and 30).

June 25–26, 1925. Second series of radiation given. A 70 per cent S.U.D. of hard roentgen rays was administered over tumor region. In addition, 55 mg. radium, screened by 1 mm. brass and 1 mm. hard rubber, placed against the roof of the mouth for seven hours.

Sept. 28, 1925. Lesion entirely healed.

Sept. 28–30, 1925. Third series of radiation therapy. Technique same as second, except the radium, which was as follows: 55 mg. radium, screened by 1 mm. brass and 1 mm. hard rubber against hard palate for four hours.

June 30, 1928. Patient is well. There is complete regeneration of bone of the hard palate (Fig. 28).

(Note). This case was diagnosed by the Registry as "Undifferentiated round cell sarcoma, origin unknown. Malignant."

Summary. This case represents a tumor of the hard palate which was variously diagnosed as endothelioma, undifferentiated round cell sarcoma, etc., and which following three series of deep roentgen-ray therapy, curettement and radium therapy, entirely healed.

3. MYELOMA

Myeloma is a very rare condition. The Registry collected during a period of five years only 9 cases of typical, and 5 cases of questionable, myeloma. We have seen, during the past seven years, since the advent of deep roentgen-ray therapy, only one case, and this was so far advanced that no treatment could be given.

Since myeloma morphologically is either a myelocytoma, lymphocytoma, plasmocytoma or erythroblastoma, and since all of

these cell elements are highly radiosensitive, the immediate response of the tumors to irradiation is very satisfactory. Unfortunately, however, myeloma is a multiple disease, involving practically all the bones of the skeleton and often replacing the entire bone marrow, with secondary metastases to the spleen, liver, kidneys, skin, etc. For this reason roentgen-ray therapy, however extensive it may be, has "quoad vitam" very little influence on the course of the disease.

4. PERIOSTEAL FIBROSARCOMA

Unlike the periosteal osteogenic sarcoma which originates from the bone-producing cambial layer of the periosteum, the periosteal fibrosarcoma has its origin in the outer fibrous layer of the periosteum, which is incapable of producing bone. As a result, the periosteal fibrosarcoma continues slowly its growth toward the soft tissues, and never invades the bone. Sometimes, especially in the advanced stages, it will produce absorption of the bone by pressure.

Microscopically the tumor is a pure fibrosarcoma of a relatively benign character. It remains encapsulated for a long period and it never produces metastases. However, if incompletely removed, it is likely to recur, and with each recurrence, the tumor becomes more anaplastic and malignant.

The treatment of choice is radical surgery. If there is a suspicion that the tumor was not removed in its entirety, or if the tumor has already recurred, prophylactic irradiation following the operation will prove of great value.

5. BORDERLINE CASES

In this group we place tumors which, although showing many signs of a benign character, are on the borderline of transforming into a malignant process. Since diagnosis is often very difficult, it is probable that many cases of "cured" bone sarcoma reported in the medical literature belong to this group or to the periosteal fibrosarcomata.

The Registry of Bone Sarcoma has therefore taken the initiative to classify every benign process, which contains suspicious criteria of malignant degeneration as a borderline case until proven definitely malignant. We desire to include in this group also two pathologically definite benign lesions, which clinically after a sufficient time has elapsed often take an undoubtedly malignant course: the *skeletal chondroma* and the *pure myxoma* or *myxochondroma* of the bone.

The *skeletal chondroma* is clinically related to osteogenic sarcoma. In the majority of cases the process begins with a single primarily benign tumor which according to Kolodny[7] "is notoriously persistent, grows to a large size, tends to recur after incomplete surgical procedures, and finally to metastasize." In other cases the tumor is generalized, appearing as multiple foci and involving practically all the bones of the skeleton. In both instances, the tumors may remain quiescent for years until some kind of trauma (accident, surgical intervention, etc.) suddenly produces a change for the worse. At this time, the cartilaginous matrix becomes richer in blood supply, the benign cell elements gradually undergo malignant degeneration, and often distinctly sarcomatous changes will result. The course from this moment on is not unlike that of osteogenic sarcoma. Generalized metastases, as a rule, form the closing chapter of the disease.

From the point of view of roentgen-ray therapy, we have to draw a sharp outline between the two stages of the chondroma. As long as the process maintains its benign character, and remains localized to one single focus, irradiation is of little benefit, and radical surgical intervention is the treatment of choice, but as soon as the lesion becomes generalized and signs of malignant degeneration appear, irradiation, in the form of deep roentgen-ray therapy, becomes of great value. This manifold behavior of the chondroma toward irradiation is easily explained by the histological changes occurring within the tumor. In the first stage, when the tumor is localized, the histological structure is that of typical cartilage. Since cartilage is highly radioresistant, the response to irradiation will be nil. As soon as the cartilage shows malignant degeneration, atypical cell elements will make their

Fig. 31. Case VIII. Multiple skeletal chondroma, showing changes in the bones of the left hand. Practically all bones of the skeleton were involved.

Fig. 32. Same as Figure 31. Four years following roentgen-ray therapy. Condition is practically arrested.

appearance, and as these elements, as a rule, are more or less radiosensitive, irradiation will result in their destruction, with the ultimate clinical arrest of the process, lasting for a period of many years.

Case VIII. *Registry No. 533, Miss N. C., aged eight.* When three years of age, in 1919, the patient caught her hand in the door and suffered what was considered a fracture of the phalanges of the left hand. The fracture was treated by immobilization, and the patient became well. In 1920, a small lump was noticed on the big toe of the right foot. This caused no pain and no further attention was paid to it. In 1922, patient began to have pain in the lower back. At the same time, a slight swelling in the sacral region was noticed. The pain in the back became more and more severe. In 1924, the patient started to lose weight and the pain became so pronounced that the patient had to stay in bed. In April, 1924, she was admitted to the Detroit Diagnostic Hospital where roentgenograms of the entire skeleton were taken and where a specimen was removed from the left iliac region for microscopic examination.

Pathologic Report. Gross examination shows the specimen to be of cartilaginous consistency. There is no apparent periosteal proliferation. Microscopic examination: Chondroma (Fig. 35). These types of tumors on flat bones of the pelvis are usually multiple and often become sarcomatous, the tendency to sarcomatous changes being most marked in the pelvic bones.

A diagnosis of multiple chondroma with possible sarcomatous degeneration was made, and the patient was referred to Harper Hospital for radiation therapy.

Findings June 30, 1924. Roentgen-ray studies were made of various parts of the skeleton. Plates of the left hand show bone resorption of practically all the second and third phalanges and of the third and fourth metacarpals. The resorption is confined especially to the shafts and has the appearance of multiple bone cysts (Fig. 31). There is also resorption of the second phalanx of the right thumb. Films of both feet show the same condition extending to the second and third phalanges on the right foot. The same condition is noted in the third phalanx of the left foot. Plates of both legs show bone resorption in the lower portion of the left tibia. There are scattered areas of resorption in the upper third of the left tibia and in the upper third of the left fibula. The right leg shows resorption of the lower end of the fibula.

Fig. 33. Same as Figure 31, showing marked changes in the pelvic bones and upper femora.

Fig. 34. Same as Figure 33. Four years following roentgen-ray therapy. Condition appears arrested. There is increased bone regeneration (sclerosis).

The upper end of the right fibula shows, in addition to bone resorption, new bone formation and areas of calcification.

Plates of the right hip show the same condition confined to the left upper thigh; there is also bone resorption with partial new bone formation extending over the lower third of the left ilium and over the entire right ilium; there is also involvement of the sacrum (Fig. 33).

Roentgen-ray examination of the head and cervical spine was negative for evidence of bone change.

The changes described show that the condition is multiple, involving practically the whole skeleton. The appearance suggests the picture of a generalized osteochondrosarcoma. Owing to the very far advanced stage and generalization of the disease, treatment is to be given only over the pelvic bones and over the upper femora, to relieve pain.

June 30 to July 5, 1924. Deep roentgen-ray therapy over the pelvis and upper femora. Dose: 110 per cent S.U.D. (720 R in air). Quality of roentgen rays 0.13 Å effective wave length, 200 kv.; 1 mm. Cu, 1 mm. Al filters, air-cooled tube, 4 ma.

Findings Nov. 7, 1924. There is remarkable improvement in the condition of the patient. The pain has entirely disappeared. While previous to the treatment, she was unable to walk, and confined to bed, about four weeks following the treatment, she started to walk again. She has gained about 20 pounds in weight. The patient is now entirely symptomless, is able to walk, play and is going to school.

In view of this unexpected improvement, it was decided to extend the treatment over all the areas involved.

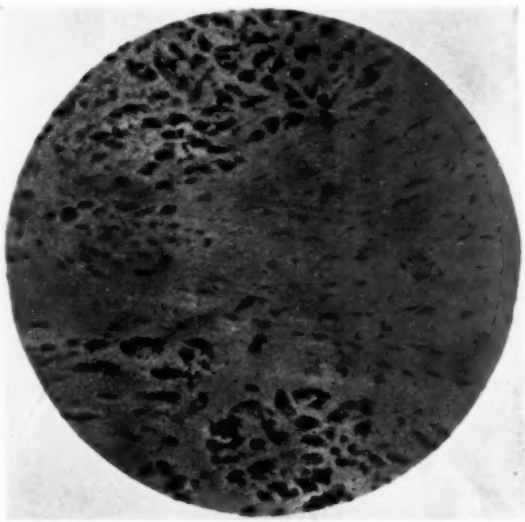


Fig. 35. Histologic section in Case VIII of Figure 33. Chondroma of bone.

Nov. 7 to 13, 1924. Deep roentgen-ray therapy given over the pelvis, both feet, legs, femora, both hands, forearms, arms and over the lumbar and lower thoracic spine. Dose: 90–110 per cent S.U.D.

There was marked reaction following this extensive irradiation, which lasted for almost two months.

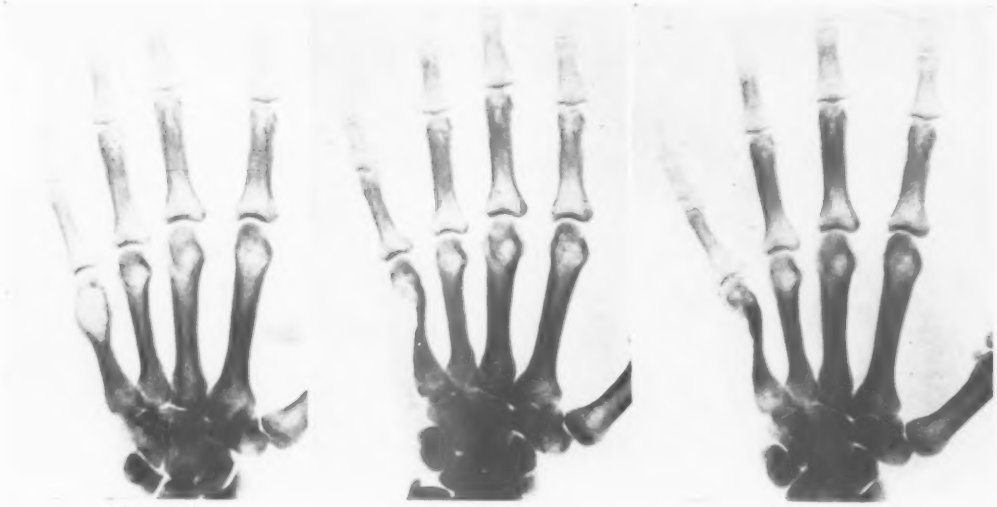


FIG. 36. FIG. 37. FIG. 38.

FIG. 36. Case IX. Myxoma of the head of the fifth metacarpal bone, with cyst-like destruction of bone.
FIG. 37. Same as Figure 36, immediately following curettage.
FIG. 38. Same as Figure 37, showing partial filling in of the bone, following postoperative roentgen-ray therapy.

Jan. 2, 1925. Patient entirely symptomless—going to school.

June 30, 1928. Patient feeling well. Roentgenograms of the entire skeleton were taken. As compared with the previous examinations, the changes are about the same except for the fact that there is increased bone regeneration (Figs. 32 and 34).

Summary. This case represents a multiple skeletal chondroma in a girl eight years of age, which in 1924 started to produce symptoms of malignant degeneration. A biopsy at this time showed chondroma with sarcomatous degeneration. (Because of the many cellular areas present, the condition was classified by Ewing in the Registry notes as multiple myeloma or endothelioma.) Following the application of two series of roentgen-ray therapy, the lesion was arrested and the patient has remained entirely symptomless.

The second condition which, although pathologically classified as a benign tumor, and which under certain conditions, may show a malignant character, is *myxoma* or *myxochondroma* of the bone. This condition was studied in all its detail by Bloodgood.[15] With regard to the treatment, Bloodgood says: "Up to the present time, there is not a single case of myxoma or myxochondroma which has remained well and free from recurrence after an operation consisting of curetting only." "Recurrence usually occurs within the first year."

From myxomatous or myxosarcomatous tumors of other locations than bone, we now know that this type of tumor usually yields well to irradiation. Because of the extreme rarity, we had the opportunity to treat only one case of myxoma of bone, the one described below. Here the lesion was first curetted and followed by radiation therapy. Contrary to the above statement of Bloodgood, the lesion has remained healed. One may rightly assume, therefore, that the irradiation which followed the curettement is responsible for the cure.

CASE IX. *Miss N. K., aged thirty-five. (This case was not registered.)*

Since 1917, the patient had complained of "soreness" localized in the region of the head of the fifth metacarpal of the right hand. The soreness had been sufficiently marked to make the patient unwilling to shake hands with anyone, on account of pressure exerted over this region. Later, swelling developed in the place of soreness, which since June, 1923, had rapidly increased in size. Roentgenograms taken in September, 1923, just previous to the operation, revealed a destruction of the head of the fifth metacarpal by a tumor mass (Fig. 36).

Sept. 5, 1923. At operation, a large part of

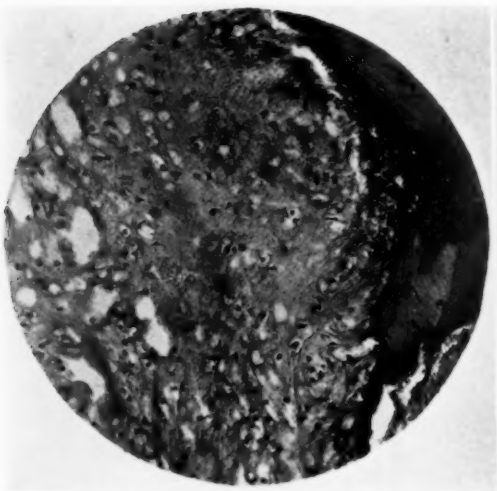


Fig. 39. Histologic section of Case IX in Figure 36. Pure myxoma of the bone.

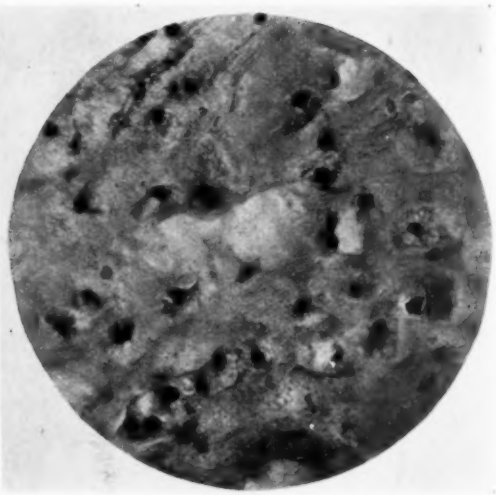


Fig. 40. Same as Figure 39. High power.

the fifth metacarpal which had been destroyed by the tumor was curetted (Fig. 37).

Microscopic findings. Myxoma of bone (Figs. 39 and 40).

Oct. 8, 1923. Patient was referred for radiation therapy. The wound is entirely healed.

Oct. 8 to 10, 1923. Deep roentgen-ray therapy given over the site of the primary lesion, as well as over the cubital and axillary lymph nodes. Dose, 90 per cent S.U.D. (600 R in air), quality of roentgen rays: 0.137 Å, 200 kv., 1 mm. Cu, 1 mm. Al as filters, air-cooled tube, 4 ma.

Dec. 21, 1923. Condition healed. There is filling in of the bone (Fig. 38).

June 30, 1928. Patient well. No evidence of recurrence.

Summary. The case represents a pure myxoma of the head of the fifth metacarpal which, following curettement and roentgen-ray therapy, has healed.

GIANT CELL TUMOR

Giant cell tumor is included in this article, because it is still considered by many as true sarcoma. As such, it is classified as the central or medullary subvariety of bone sarcoma, and is included in many statistics dealing with the "remarkable" therapeutic results of osteogenic sarcoma. The question is further complicated by the fact that in the different countries and even within the same country, various names are used: Tumeur à myéloplaxes, myeloid sarcoma, giant cell sarcoma, myeloma, giant cell sarcoid, benign giant cell sarcoma of the epulis type, etc., are only a few of the terms used in describing this condition.

The Registry of Bone Sarcoma accepted the term "benign giant cell tumor." As Codman[1] says: "The term used by Bloodgood to replace the old term giant cell sarcoma is accepted by the Registry; we feel very sure of a well marked separation of these tumors as a clinical entity." This well marked clinical, and we may add, pathological entity, was further proven by the subsequent registration of hundreds of cases.

The Benign Character of the Giant Cell Tumor. From the standpoint of treatment, of course, the important question is whether giant cell tumor is of a malignant or of a benign nature. The first author ever to recognize the benign character of the lesion was Paget[16] who in 1853, wrote: "The myeloid tumors usually occur singly, they generally grow slowly and without pain, they are not apt to recur after complete removal, nor have they in general any feature of malignant disease." This benign feature of the lesion was reaffirmed by Nélaton[17] who in 1860 wrote a very comprehensive monograph on the subject. However, Gross,[18] in 1879, for the first time, reported 5 cases of benign giant cell sarcoma which underwent malignant degeneration. From this time on, the

FIG. 41. Case X. Tumor of the left ilium, roentgenologically diagnosed as benign giant cell tumor.

FIG. 42. Same as Figure 41, showing filling in of the bone defect following roentgen-ray therapy.

question of benignity or malignancy of the giant cell tumor led to some of the most passionate disputes ever known in medical literature. Thus, while Bryant,[19] Bloodgood,[20] Martland,[21] Stone and Ewing,[22] Codman,[23] Meyerding,[24] and others, considered the benign character of the lesion as unquestionable, Stewart,[25] Auge and Roux,[26] Waugh and Turner,[27] Shattock,[28] MacGuire and McWhorter,[6] and especially Coley,[5] repeatedly emphasized that some of the giant cell tumors are distinctly malignant, and that they produce metastases. Not even the Registry could settle the question definitely. While Codman[23] is "convinced that they are benign," Kolodny,[7] after analyzing the same material, says: "The question as it stands today is whether or not a giant cell tumor is always benign. From the evidence on hand, this question is to be answered in the negative." At the same time Goforth[29] writes: "Giant cell tumors constitute a series. Those at the lower end of the scale show relatively adult fibrous stromas, and are essentially benign. They exhibit more cellular and active stromas, composed chiefly of relatively immature fibroblastic cells, and become increasingly more locally aggressive as the scale is ascended."

In our estimation, giant cell tumor is essentially benign, but such a differentiation as that of Goforth is of some help from the therapeutic standpoint. It is comprehensible that a rather cellular tumor with immature fibroblastic elements should show a great tendency toward recurrence, especially if incompletely removed. Moreover, since with each recurrence the tumor is apt to become more and more virulent, it is plausible that finally a malignant degeneration of the lesion should follow. Stone and Ewing[22] described such a case. We are convinced, however, that the majority of cases described in the literature as primarily malignant giant cell sarcomata are based on mistaken or incomplete diagnoses.

CASE X. *Mr. G. C., aged forty. (Case not definitely classified by the Registry.)*

Onset of disease in 1918, with occasional pain in the region of the left sacroiliac synchondrosis. The pain was intermittent, and appeared to be of a rheumatic character; therefore the patient did not seek medical advice.

During 1924, the pain became more pronounced and was of such a shooting character

Fig. 43. Histologic section of Case x in Figure 41, showing small spindle cell variety of osteogenic sarcoma.

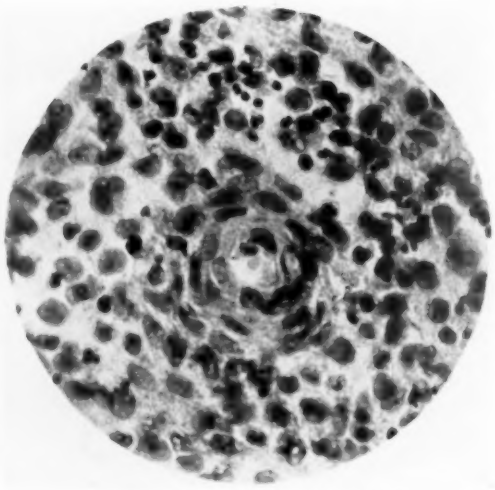


Fig. 44. Same as Figure 43. High power.

that the patient consulted a physician. A roentgen examination was made, and the condition diagnosed as a benign giant cell tumor. Several superficial roentgen treatments were given, without result. Since the condition was steadily growing worse, the patient was referred to Harper Hospital on Dec. 8, 1924.

Dec. 8, 1924. Stereoscopic roentgen examination of the pelvis and sacroiliac regions shows an extensive destruction of bone in the left sacroiliac region, with the process limited almost entirely to the ilium (Fig. 41).

The long history of the disease, as well as the roentgenologic findings, suggested a bone tumor of the benign giant cell type.

Operative Findings Dec. 8, 1924. Incision was made to the left of the spine over the sacroiliac joint. A tumor mass consisting of several jelly-like nodules was curetted, and a frozen section made by Dr. Morse. This showed a spindle cell sarcoma with islands of round cells. On account of this finding, the wound was closed without further procedure, and immediate deep roentgen therapy was instituted. This was done while the patient was still under anesthetic, and a massive dose was given.

Since the examination revealed that there was enlargement of the lymph nodes in the right inguinal region about 1 to 4 cm. in diameter, it was thought that this might represent a metastatic process, and deep roentgen therapy was extended to practically the entire lymphatic system and lungs. Thus the following treatment was given:

Dec. 8 to 13, 1924. First deep roentgen therapy, over the pelvis, chest and entire lymphatic system (90 per cent S.U.D. over the individual areas). Quality of roentgen rays, 0.137 Å effective wave length, 200 kv., 1 mm. Cu, 1 mm. Al filters, water-cooled tube, 25 ma.

Microscopic sections were made in the meantime, and the following is the report of Dr. P. F. Morse: The histoid structure and the relation of blood vessels leads to a diagnosis of a small spindle cell type of sarcoma (Figs. 43 and 44), but the infiltration of the mass with eosinophile cells and the areas which have a granulomatous appearance, as well as those areas in which the cells appear to contain an increased quantity of fat, strongly suggest that this condition may belong to the group of Paget's disease (osteitis deformans).

Feb. 10, 1925. The pain has entirely disappeared and the patient has become symptomless. However, he was only permitted to walk with crutches.

Roentgen-ray examination of the pelvis shows the condition to be practically the same. There is no evidence of bone regeneration, and no evidence of further bone destruction. The enlarged lymph nodes in the left inguinal region have disappeared. General condition of the patient good.

Feb. 10 to 12, 1925. Second deep roentgen treatment over the pelvis. Dose and technique the same.

May 12, 1925. Patient is symptomless. Roentgen examination of the pelvis shows evidence of increased calcium deposit in the former bony defect. Patient was advised to continue to walk on crutches for at least a period of six months, until the complete filling in of the bone defect in the lumbosacral region had taken place.

May 12 to 13, 1925. Third series of deep roentgen therapy. Dose and technique the same.

Aug. 30, 1926. Patient is entirely symptomless. Walking without crutches. Patient is carrying on his usual occupation (supervisor of golf course).

Roentgen studies of the pelvis show evidence of filling in of the former bone defect, except a small area in its upper portion (Fig. 42). The examination is entirely negative for evidence of metastasis or further extension of the disease.

Summary. This case is interesting because the history of the disease, as well as the roentgenological findings, suggest a benign giant cell tumor, while the microscopic report is that of a sarcoma. Extensive deep roentgen-ray therapy was applied as for sarcoma. Later the patient died from a perforated appendix, and at the time of death there was no evidence of any malignancy.

It is difficult to decide whether or not the case represents a benign giant cell tumor with malignant degeneration, or whether it was a malignant process from the onset. The case, however, belongs to one of those rare occurrences which forms the topic, as Kolodny[7] says, of an "old trodden path of discussion."

The Value and Principles of the Surgical Treatment. The change in the conception of the giant cell tumor from that of a malignant sarcoma to that of a benign tumor had its origin in the therapeutic measures applied. While as recently as 1910, amputation belonged to the routine procedure, this later was supplanted by the more conservative resection, and still later by the simple curettage.

At the present time, the more or less standard surgical treatment consists in extensive curettement of the involved bone with swabbing out of the curetted area with alcohol and carbolic acid or zinc chloride. An analysis of the results obtained reveals that the method, far from being ideal, has the following disadvantages:

1. Recurrence occurs shortly following the curettage in a great number of cases. Bloodgood,[20] who is the greatest advocate of the above method of treatment, in his series of 77 cases in 1923 reports recurrence in 16 of the 42 cases treated primarily by curettage. Kolodny,[7] analyzing the cases of the Registry, says: "Recurrence seems to be frequently unavoidable and is observed in about 20 per cent of all cases treated by the single curettage alone." Of course, the figures of the Registry are incomplete with regard to the total cases treated, since the unfavorable results are more apt to be left unregistered than the favorable ones. This is clearly proven by the reports of some other investigators, who gave collective statistics of all the cases treated and who obtained much larger numbers of recurrences. MacGuire and McWhorter,[6] for example, report 6 recurrences out of 13; Coley,[5] 6 out of 21; Lewis,[30] in giant cell tumors of the spine, 5 out of 11, etc. These figures take on a still more gloomy appearance when we consider that the cases of giant cell tumor primarily treated by curettage represent only a well-selected fraction of the total cases coming under observation, and where more radical methods of treatment (amputation, resection, or no treatment) were used.

2. In many cases, curettage leads to secondary infection, resulting sooner or later in amputation. MacGuire and McWhorter,[6] in their series of 13 cases had one infection; Platou[31] had 2 out of 8; Coley,[5] 6 out of 21. In the case of Coley, of the 6 infected cases, 2 died later of generalized metastases, one of nephritis, one could not be located, and only 2 got well after amputation.

3. Repeated surgical injury or infection sometimes leads to malignant degeneration of the benign giant cell tumor. Stone and Ewing[22] described the possibility of such an occurrence. Thus Ewing[13] says: "I have never known these tumors to produce metastases and I have been unable to find authentic records of such complications, but it seems possible that by curettage, groups of viable cells could be dislodged from the tumor and pass into the blood vessels."

Without wishing to be dogmatic, we find that by taking into consideration the above factors, and after comparing the number of cases treated by curettage with the total number of cases coming under observation, the percentage of amputa-

tions (and thus one may say of the surgical failures) is not infrequently as high as 50 per cent. Of the 77 cases of Bloodgood's[20] collected in 1923, twenty-nine cases finally came to resection and 16 cases to amputation. Of the 20 cases reported by MacGuire and McWhorter,[6] 2 cases came to resection and 12 cases to amputation. Of Platou's[31] 10 cases one came to resection and 4 to amputation. Of Coley's[5] 50 cases, 2 came to resection and 16 to amputation. The better results of Coley are due to the fact that in many cases mixed toxins and radiation therapy were used either alone or in combination with the surgical methods.

The Value and Principles of Roentgen-ray Treatment. In view of the above facts, the question arises whether or not roentgen-ray therapy, for the reasons already given, could improve the surgical results and if so, to what extent.

Herendeen[32] was the first to report, in 1924, a series of giant cell tumors treated by radiation alone. The results were so encouraging that Herendeen ventured the following statement: "From the study of all the cases and the course following treatment, it does not seem premature or too optimistic to say that it is believed that most of them can look forward to a complete cure and restoration of function." All Herendeen's (16) cases were filed with the Registry of Bone Sarcoma. Since that time, other cases have been registered so that Codman,[2] in establishing the "by-products" of the Registry considers as one of them "the impersonal proof that cases of giant cell tumor may be cured by radiotherapy." Kolodny,[7] reproducing several cases of Herendeen's, says: "During recent years, a further and most significant step has been taken toward conservative treatment of giant cell tumor, it consists of substituting radiation therapy, either roentgen ray or radium, for surgical operations;" and again: "The experience accumulated in a few medical institutions, especially at the Memorial Hospital in New York, is of such weight that it eliminates any doubt as to the very great value of radiation therapy as a primary therapeutic measure in giant cell tumor."

Now that the value of roentgen-ray therapy in the giant cell tumor is recognized, it seems appropriate to try to establish definite indications for the use of surgical measures or irradiation alone, or a combination of the two. We believe that we are justified in making the following practical rules:

1. Every case of benign giant cell tumor should be primarily irradiated. Since the results obtained by the irradiation closely depend on the capacity of the bone to regenerate, in middle-aged and elderly persons one may resort, especially if the lesion is small and is in a weight-bearing bone, to primary curettage or resection of the tumor and the use of a bone graft. In children and young adults, however, surgery should never be undertaken before irradiation is tried.

2. All cases treated by curettement, where there is suspicion that the tumor could not be removed *in toto*, should be followed by irradiation. In our estimation, roentgen-ray therapy here is of greater benefit than the application of radium. One should never use radium locally in the curetted area. Aside from the danger of infection, radium produces too much local destruction, and thus makes the regeneration of the bone very difficult, if not impossible.

3. In larger lesions, if primary curettage is done and roentgen-ray therapy is applied following the operation, the results often are not so good as though roentgen-ray therapy had been given without curettage. The large shell-like cavity produced by the operation, aside from the constant danger of a pathological fracture, is not likely to form new bone as quickly as the untreated tumor where there is already some natural tendency to bone regeneration.

4. Amputation should never be performed without the use of irradiation first, regardless of the extent of the lesion. Often the best results from roentgen-ray therapy are obtained in such cases.

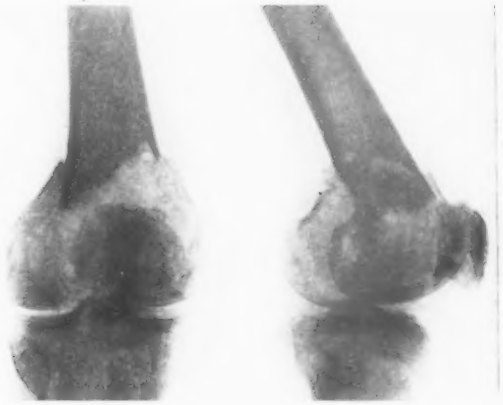
The following case proves the importance of the above rules in an unquestionable manner:

Case XI. *Registry No. 528. Mr. O. L., aged twenty-nine.*

Onset of the disease in August, 1923, with

A B

FIG. 45. Case XI. Benign giant cell tumor of lower end of left femur.



A B

FIG. 46. Same as Figure 45. Following infection at biopsy and two series of deep roentgen-ray therapy, the bone cavity failed to fill in. Later, spontaneous fracture occurred.

pain in the left knee. At the beginning, the pain was only occasional, but after November, 1923, it was more or less continuous, considerably worse at night. In December, 1923, a swelling appeared just above the left knee joint. Since February, 1924, the pain had become so severe that the patient could not sleep. The swelling was increasing in size. At this time, functional disturbance was present.

Findings April 13, 1924. There is a marked swelling just above the left knee joint. Roentgenograms show considerable bone destruction of the lower end of the left femur (Fig. 45). The movements of the knee joint are normal and are not painful. Patient states, however, that there is pain on weight bearing.

Operation April 13, 1924. Section of tissue taken for microscopic examination.

Microscopic findings. Benign giant cell tumor of bone (Fig. 48). Patient referred for radiation therapy.

Findings April 18, 1924. The wound is healing. There is a slight drainage from the tube which was inserted in the wound. General condition of the patient very good, and there is no evidence of metastasis.

April 14 to 18, 1924. First series of deep roentgen-ray therapy over the lower third of the left femur. Dose: 90 per cent S.U.D.; quality of roentgen rays 0.137 Å effective wave length; 200 kv.; 1 mm. Cu, 1 mm. Al as filters, water-cooled tube, 25 ma.

Following the treatment, there was increase in the size of the swelling. Patient was under the impression that the condition was getting worse.

Findings June 2, 1924. The swelling of the knee has somewhat increased. The roentgen studies show that the process has extended and at this time there is breaking through of the cortex at the internal condyle of the femur. General condition of the patient good.

FIG. 47. Same as Figure 46, showing specimen after amputation. There is a bony shell cavity of the lower end of the left femur, infected and without tendency to new bone formation.

June 2, 1924. A second series of deep roentgen-ray therapy was given. Dose and technique the same.

Findings July 15, 1924. Patient states that

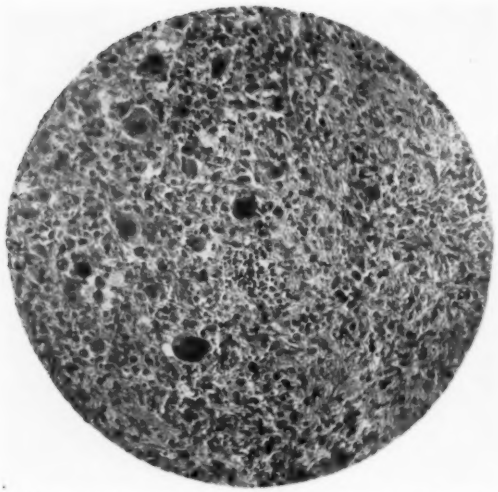


Fig. 48. Histologic section of condition shown in Figure 45. Benign giant cell tumor.

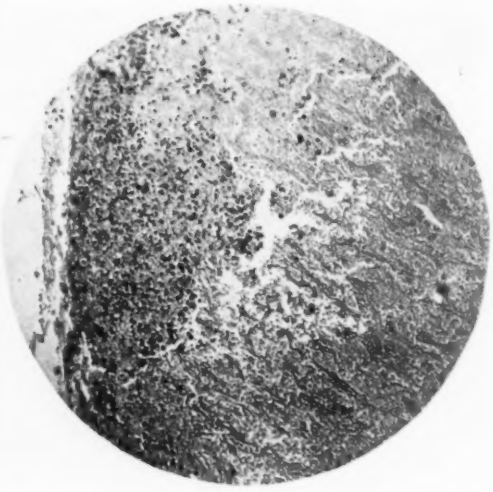


Fig. 49. Histologic section of condition shown in Figure 46. No tumor elements present. Destructive, purulent infectious process with no effort toward regeneration.

for the past four weeks, he has noticed a marked swelling of the left knee joint, and during the same time there has been swelling of the inguinal lymph nodes on the left side. About two weeks later, the knee started to drain through the drainage tube, and as a result of this drainage, the swelling reduced in size. At the same time, there was reduction in the size of the inguinal lymph nodes.

On examination July 15, 1924, the swelling of the knee joint is somewhat less than at the previous examination. There is still a rather profuse discharge through the drainage tube. The lymph nodes in the left inguinal region are enlarged (from 1 to 5 cm. in diameter), they are slightly painful on manipulation, and apparently represent an infectious process. Roentgenograms show the condition of the left lower femur to be about the same. At any rate, there has been no extension of the lesion.

March 15, 1925. Condition of the lesion is about the same. There is still evidence of drainage from the incision. Roentgenograms at this time show that a pathological fracture has occurred at the site of the former lesion (Fig. 46). The patient has considerable pain and is losing weight.

May 14, 1925. Since the lesion failed to heal, amputation of the left femur at about the middle of the thigh was done.

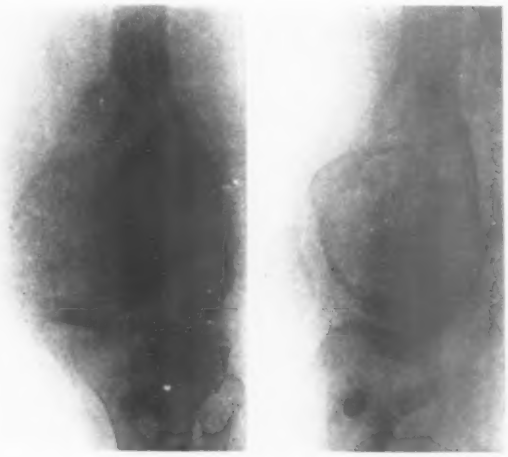
Pathological Report. The gross specimen shows a bony shell cavity of the lower end of the left femur, infected, and without any tendency to new bone formation (Fig. 47).

Microscopic Findings. 7581–25, Dr. P. F. Morse. Destructive purulent infectious process with no effort at regeneration. There is no neoplastic process present (Fig. 49).

July 5, 1928. The patient is well. There is no evidence of metastasis.

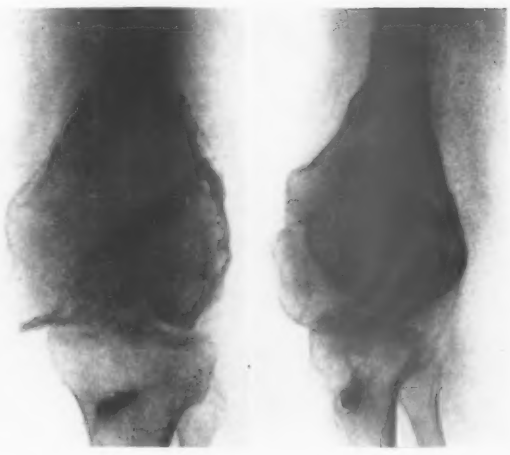
Summary. This case represents a benign giant cell tumor of the left lower femur which became infected at biopsy. The large bony shell cavity produced at the operation failed to heal following the application of two series of deep roentgen-ray therapy. About one year later, amputation of the lower left femur had to be performed. The patient is now well, and no metastases have developed.

Dosage and Technique. Because of the reasons expounded above, we prefer to use, in the roentgen-ray treatment of giant cell tumors, smaller doses, repeated at shorter intervals, rather than big, massive doses repeated at longer intervals. As a rule, a dose of 90 per cent S.U.D. is given which at subsequent exposures is reduced to 70 per cent S.U.D. then to 50 per cent S.U.D. The treatments are repeated at six weeks to two months' intervals until a healing is obtained. In some instances we administer as many as six to seven series of treatments. Deep roentgen-ray therapy, because of the higher penetration and the more uniform distribution, is preferred to radiation with rays of long wave length. (We apply rays of 0.13–0.14 Å effective



A B

FIG. 50. Case XII. Benign giant cell tumor of the lower end of the femur.



A B

FIG. 51. Same as Figure 50. Following the application of three series of deep roentgen-ray therapy, there was healing with complete bone regeneration.

wave length, 200 kv., 1 mm. Cu, 1 mm. Al as filters.)

As a rule, a marked reaction appears shortly following the application of the first dose. The reaction is so typical that it is almost of differential diagnostic value. It consists in the appearance of redness of the skin starting about one to two weeks after the treatment, and lasting for a period of several months. At the same time, there is marked edema and swelling of the soft tissues. The tumor itself shows a considerable enlargement and there is, as shown by roentgenograms, an expansion of the cortex of the bone with thinning of the outline and a washed out appearance of all the structures. The general impression at this point is that the condition is growing worse. It is not surprising, therefore, to see that in many instances, other methods of treatment are hurriedly resorted to, especially radical surgery, before the reaction on the tumor produced by the irradiation has developed to its fullest extent. However, after two to four months following the treatment, one will see the reaction subside, the tumor gradually diminishes in size, and repeated roentgenograms will show a rapid regeneration of the bone, resulting in ossification and sclerosis. Within one year, there is healing with complete restoration of the normal function.

It is of importance that during the period immediately following the treatment, the part be completely immobilized, so that pathological fractures may be avoided. These are especially liable to occur during the climax of the reaction produced.

One cannot sufficiently emphasize the danger of over-irradiation of the benign giant cell tumor. As shown by Ewing,[10] the over-irradiation of the normal bone results in destruction of the natural tendency of the regenerative process. While such a procedure may effect a disappearance of all the tumor elements, because of the reduced regenerative capacity of the normal bone, a filling in of the destroyed area will follow only very slowly or not at all. Moreover, a chronic productive radiation osteitis may develop with atrophy and demineralization of the bone irradiated. Such a condition invariably leads to ultimate amputation or other mutilating operative procedures. Thus, while pathologically there may be a complete healing of the tumor, clinically the patient will continue to suffer until a radical operation will remove all the over-irradiated bone.

By taking into consideration all the above factors, we believe that roentgen-ray therapy of the benign giant cell tumor can be carried out in such a manner that the results obtained should surpass the results of any other method of treatment. Only one case of giant cell tumor is

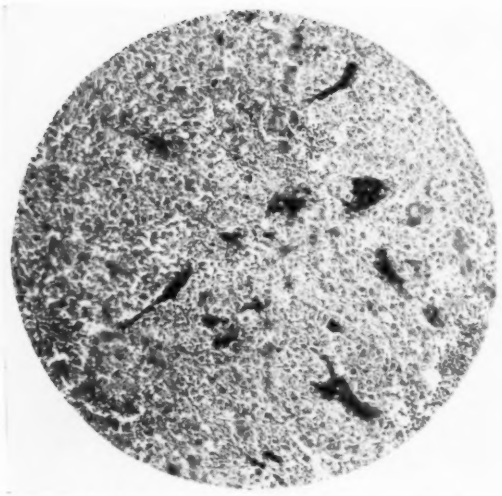


Fig. 52. Histologic section of case in Figure 50. Benign giant cell tumor.

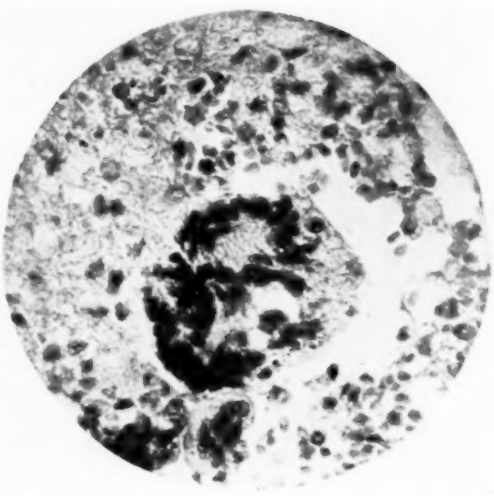


Fig. 53. Same as Figure 51. High power, showing typical giant cell.

included here merely to illustrate our method of procedure.

Case xii. *Registry No. 529. Miss H. F., aged twenty.*

Onset of the disease in 1921 with pain in the left knee. About half a year later, the knee was operated upon, and a large cyst of the lower end of the femur was found. The patient was advised not to use the leg, and she was confined to bed for a period of a year and a half. In June, 1923, she came to Harper Hospital for treatment.

Findings June 25, 1923. There is marked swelling of the lower third of the thigh, the maximum swelling being just above the knee joint. The swelling produces a dull aching pain, more pronounced at night.

Roentgenograms show a condition of the lower end of the left femur which was diagnosed as benign giant cell tumor (Fig. 50).

June 29, 1923. Histopathological report: Benign giant cell tumor (Figs. 52 and 53).

July 16, 1923. First series of deep roentgen-ray therapy, over the lower third of the left femur. Dose, 90 per cent s.u.d.; quality of roentgen rays 0.137 Å effective wave length; 200 kv.; 1 mm. Cu, 1 mm. Al as filters, air-cooled tube, 4 ma.

Sept. 24, 1923. Patient had considerable pain following the treatment, lasting for a period of four weeks. During that time, the swelling has increased, and there was redness of the skin.

Sept. 24 to 25, 1923. Second series of deep roentgen-ray therapy. Dose 70 per cent s.u.d. Technique same.

Findings Nov. 28, 1923. Condition of patient markedly improved. There is no pain, and she is able to walk. Roentgenograms show beginning bone regeneration.

Nov. 29 to 30, 1923. Third series of deep roentgen-ray treatments. Dose 70 per cent s.u.d. Technique same.

July 30, 1924. Condition healed. Patient is walking without difficulty. Roentgenograms show marked bone regeneration (Fig. 51).

June 30, 1928. Patient well.

Summary. This case is one of benign giant cell tumor which recurred after operation. Following the application of three series of deep roentgen-ray therapy, there is healing with complete bone regeneration.

SUMMARY AND CONCLUSIONS

The roentgen-ray therapy of primary malignant bone tumors and of benign giant cell tumors is governed by the following rules, which are the result of the primary influence of the roentgen rays upon the highly complicated tumor tissues:

1. Cellular tumors without much stroma and rich in blood supply, though clinically and from the surgical viewpoint, very malignant, may be made to disappear entirely by irradiation.

2. Tumors of the adult type, especially when rich in mature intercellular structures (cartilage, bone) and poor in blood

vessels, may prove entirely refractory to irradiation, while surgical procedures may lead to excellent results.

3. In tumors of the intermediate type, the more undifferentiated cells may be made to disappear and the growth of the more adult cells may be retarded by irradiation, so that they produce an abundance of calcific (cartilaginous and osseous) intercellular substance. A marked sclerosis, with considerable prolongation of life, often results in such cases. In other instances, postirradiation surgical measures are of distinct value.

The different types of primary malignant bone tumors and the benign giant cell tumor are discussed individually.

Decisive proof is brought that roentgen-ray therapy is one of the most powerful assets in the treatment of all varieties of primary malignant bone tumors, as well as in the benign giant cell tumor. "Five year cures" are possible even in cases with extensive metastases and where no other methods of treatment could be of benefit.

It is the contention of the authors, therefore, that the present standard methods of treatment of bone sarcoma and of benign giant cell tumors need a complete revision. Irradiation, in the form of deep roentgen-ray therapy, should find a more extensive application in all forms of bone sarcoma and giant cell tumor, operable or inoperable, whether in combination with surgical measures, mixed toxins, or the more recent lead therapy.

It remains, then, for the Registry of Bone Sarcoma to collect more complete statistical evidence approving or disproving such a procedure. The Registry has abundantly succeeded in establishing a standard nomenclature and standard criteria of classification, and we are confident that it will now succeed in establishing more or less standard measures of therapeutics.

REFERENCES

1. Codman, E. A. The registry of cases of bone sarcoma. *Surg., Gynec. & Obst.*, 1922, xxxiv, 335–343.
2. Codman, E. A. Registry of Bone Sarcoma. Part I. Twenty-five criteria for establishing the diagnosis of osteogenic sarcoma. Part II. Thirteen registered cases of "five year cures" analyzed according to those criteria. *Surg., Gynec. & Obst.*, 1926, xlii, 381–393.
3. Eising, E. H. The diagnosis of sarcoma in the bone. *J. Am. M. Ass.*, 1923, lxxx, 1429–1432.
4. Bloodgood, J. C. The diagnosis and treatment of bone lesions: a brief summary of the salient features. Am. J. Roentgenol. & Rad. Therapy, 1923, x, 42–47.
5. Coley, Wm. B. Prognosis in giant cell sarcoma of the long bones, based upon the results in a series of fifty cases. *Ann. Surg.*, 1924, lxxix, 321–357; 561–595.
6. MacGuire, C. J., Jr., and McWhorter, J. E. Sarcoma of bone; an analysis of fifty cases. *Arch. Surg.*, 1924, ix, 545–592.
7. Kolodny, Anatole. Bone sarcoma. The primary malignant tumors of bone and the giant cell tumor. *Surg., Gynec. & Obst.*, 1927, xliv, Suppl. 1, 1–214.
8. Coley, Wm. B., and Coley, B. L. Primary malignant tumors of the long bones (end results in 170 operable cases, including a small group of malignant central sarcoma). *Arch. Surg.*, 1926, xiii, 774–836; 1927, xiv, 63–141.
9. Greenough, R. B., Simmons, C. C., and Harmer, T. W. Bone sarcoma; analysis of cases from 1911 to 1921, admitted to the Massachusetts General Hospital, and the Huntington Memorial Hospital. *J. Orthop. Surg.*, 1921, iii, 602–630.
10. Ewing, J. Tissue reactions to radiation. Am. J. Roentgenol. & Rad. Therapy, 1926, xv, 104.
11. Evans, Wm. A., and Leucutia, T. Deep roentgen therapy of neoplastic pulmonary metastases. Am. J. Roentgenol. & Rad. Therapy, 1924, xi, 35–50.
12. Connor, C. L. Endothelial meyloma, Ewing. *Arch. Surg.*, 1926, xii, 789–829.
13. Ewing, J. A review and classification of bone sarcomas. *Arch. Surg.*, 1922, iv, 485–533.
14. Kolodny, Anatole. Angio-endothelioma of bone. *Arch. Surg.*, 1926, xii, 854–866.
15. Bloodgood, J. C. Bone tumors, myxoma, central and periosteal. *Ann. Surg.*, 1920, lxxii, 712–724.
    Bloodgood, J. C. Bone tumors, metastasis to lungs from a pure myxoma. *Ann. Surg.*, 1923, lxxvii, 106–107.
16. Paget, J. Lectures on Surgical Pathology, 1853, Lindsay and Blackston, Ltd., London, i, 446, ii, 212.
17. Nélaton. Tumeurs bénigns des os ou tumeurs à myeloplaxes. Paris, 1860, 364.
18. Gross, S. W. Sarcoma of long bones, based on a study of one hundred and sixty-five cases. *Am. J. M. Sc.*, 1879, lxxviii, 17–57; 338–377.
19. Bryant, T. H. Tumors of bone. *Am. J. M. Sc.*, 1874, 485.
20. Bloodgood, J. C. Bone tumors. *Ann. Surg.*, 1919, lxix, 345; Benign giant cell tumor of bone; diagnosis and conservative treatment. *Am. J. Surg.*, 1923, xxxvii, 105–112.
    Bloodgood, J. C. Giant cell tumor of bone and the specter of the metastasizing giant cell tumor. *Surg., Gynec. & Obst.*, 1924, xxxviii, 784–789.
21. Martland, H. S. Primary bone tumors; their classification with special reference to benign giant cell tumor. *Proc. N. York. Path. Soc.*, 1921, xxi, 102.
22. Stone, W. S., and Ewing, J. An unusual alteration in the natural history of giant cell tumor of bone. *Arch. Surg.*, 1923, vii, 280–296.
23. Codman, E. A. The nomenclature used by the

Registry of Bone Sarcoma. Am. J. Roentgenol. & Rad. Therapy, 1925, xiii, 105–126.
24. Meyerding, H. W. Benign foreign body giant cell tumors in the long bones. *J. Am. M. Ass.*, 1924, lxxxiii, 1323–1329.
25. Stewart, M. J. Observations on myeloid sarcoma, with an analysis of fifty cases. *Lancet*, 1914, ii, 1236–1242.
26. Auge, A., and Roux, G. Tumeur du femur à éléments géants; amputation haute; recidive in situ et généralisation en deux mois. *Bull. de l'Assoc. franc. p. l'étude du cancer.*, 1922, xi, 616–628.
27. Waugh, T. R., and Turner, W. G. Giant cell sarcoma of femur (epulis type) with metastasis in femoral vein. *Ann. Surg.*, 1923, lxxviii, 846–852.
28. Shattock, S. G. Pathological research in sarcoma of the long bones. *Brit. J. Surg.*, 1923, xi, 127–130.
29. Goforth, J. L. Giant cell tumor of bone. *Arch. Surg.*, 1926, xiii, 846–870.
30. Lewis, Dean. Primary giant cell tumors of the vertebrae. *J. Am. M. Ass.*, 1924, lxxxiii, 1224–1229.
31. Platou, E. Osseous cysts and so-called giant cell sarcoma. *Ann. Surg.*, 1918, lxvii, 312.
32. Herendeen, R. E. The roentgen ray in the treatment of giant-cell tumors. Am. J. Roentgenol. & Rad. Therapy, 1924, xii, 117–126.
Herendeen, R. E. Diagnosis and results in the radiation therapy of some medullary bone tumors. *Radiology*, 1926, vii, 140–143.

PHYSICAL AND BIOLOGICAL PROBLEMS IN HELIOTHERAPY

III. THE CALIBRATION OF THE MERCURY VAPOR LAMP IN REPRODUCIBLE UNITS FOR CLINICAL PURPOSES*

BY

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I. INTRODUCTION

DURING the past two years, we have carried out an extensive study of the behavior of the mercury vapor lamp, with the viewpoint and the needs of the clinic in mind. We introduced the "ultraviolet unit," which produces an average erythema reaction on normal adult skin.[1] We then constructed a simple measuring device consisting of a cadmium photoelectric cell in an amplification circuit.[2] This paper relates our experiments dealing with the problem of dosimetry. In previous publications, the photochemical test as developed by Keller, based on the starch iodine reaction, was recommended for clinical purposes. It seemed to us, however, particularly important to investigate the possibility of establishing, for the ultraviolet emission of this type of lamp, a reproducible unit which could be linked up with the biological effect. In logical order it involves: (1) a study of the relative intensities of the biologically important lines in the mercury vapor spectrum (3100 to 2500 Angströms) during one thousand hours of burner life; (2) measurements of the total intensity of the emission of a quartz mercury vapor burner; (3) simultaneous measurements with the photoelectric cell; (4) performance of one of the simpler photochemical tests in order to define its limitations, and (5) controls on a sufficient number of patients for the purpose of establishing an average erythema reaction or a skin tolerance dose.

II. DESCRIPTION OF APPARATUS

In all investigations, a mercury lamp of well-known make has been used. It had a spherical hood of 36 cm. diameter. The construction of the burner was based on that of the mercury rectifier.[3] Its transformer was connected to the 110 v.a.c. line. An image of the burner was thrown on the slit of a quartz spectrograph by means of a planoconvex quartz lens. The collimating and camera lens of the spectrograph were planoconvex quartz lenses of 5 cm. aperture and 37.5 cm. focal length

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for $\lambda = 6563$ Å. The dispersing system was composed of two 60° Cornu prisms of 4.4 by 7.5 cm. face. This system has a large aperture and a focal surface which is sufficiently plane over the region studied. A micrometer screw with axis parallel to this focal plane carried the thermocouple which could thus be moved at will along the plane. The collimator slit and the thermocouple slit were each 0.5 mm. wide. The thermocouple was an Ag-Bi linear couple with seven junctions of 7 ohms resistance, constructed by Professor H. M. Randall. The thermocouple E.M.F's. were measured by a Leeds Northrup high sensitivity galvanometer of 18.8 ohms resistance and a sensitivity of 10^{-7}v per millimeter. Ten ohms resistance in series with the galvanometer and couple gave nearly critical damping. Deflections were read on a scale at a distance of 7 meters.

The same galvanometer with a low resistance shunt was used with a single junction thermocouple to measure the total radiation of the burner. The sensitivity of this system was checked before and after each reading by use of an undervolted lamp operated at a fixed potential and distance. The photoelectric cell was mounted in a light-proof brass box with a shutter and placed at a distance of 50 cm. from the burner. As its dark discharge potential (glow potential) was close to 250 volts, 230 volts D.C. from the storage battery were applied to the cell and checked continuously by a Weston precision voltmeter in parallel. A Leeds Northrup Type P galvanometer (sensitivity 8.3×10^{-10} amperes per millimeter, resistance 1100 ohms) with 10,000 ohms resistance in series gave sufficient deflection for the required readings. As photochemical test, we selected the starch iodine reaction as originally employed by Bering and Meyer,[4] in its modification by Keller.[5] A detailed description of the test is found in the first article of this series.[1] It need only be recalled here that the ultraviolet unit or average erythema reaction is the time necessary for the completion of the chemical reaction. The distance between burner and test solution has to be doubled when exposing the human body.

III. EXPERIMENTAL WORK

In order to study the fundamental electrical characteristics of such a burner, a voltmeter and an ammeter with a rheostat for balancing slight variations in the current were arranged in the circuit (Fig. 1). The voltmeter reads, therefore, the potential drop over the ammeter which is

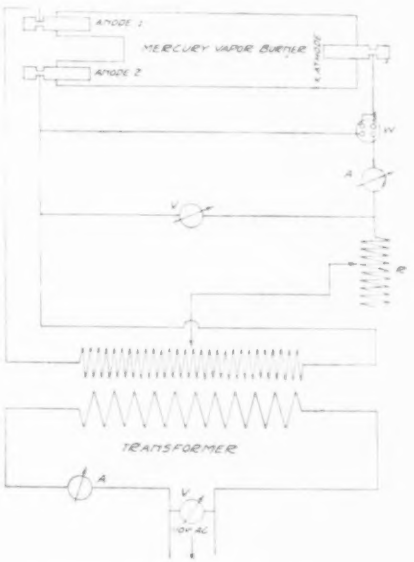

FIG. 1. Schematic diagram of the lamp circuit. Voltmeter (V), ammeter (A), wattmeter (W), and rheostat (R) in the primary and burner circuit.

negligible in this case. For recording the power input, a wattmeter was placed in the burner circuit. The change of potential and current could be recorded every minute from the time of lighting the burner until the point of constancy; it appeared that approximately twenty-five to thirty minutes are required to reach the electrical equilibrium (Fig. 2). This procedure has been repeated and verified numerous times on at least twelve burners. Schall and Alius,[6] and Hörnicke[7] have come to the same conclusions. It is at variance with the statement of some manufacturers who believe that only five minutes are required to reach the equilibrium. When comparing the power input and the ultraviolet emission, the same type of voltage-current characteristic as reported by Harrison and Forbes[8] with a specially constructed burner was encountered; the current drawn

amounted to about 2.75 amperes for all burners over a fairly wide range of potential, the change of which affected the output of the lamp much more than any other factor. Both thermocouple and photoelectric cell record this (Fig. 2); the latter is important clinically because the part of the spectrum in which we are interested

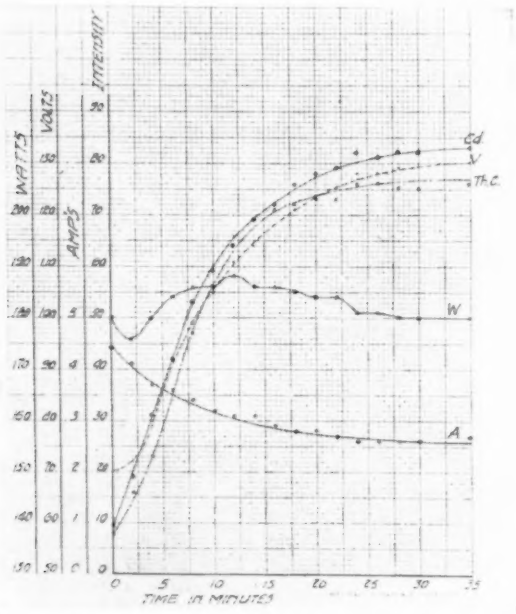

Fig. 2. The changes of potential across the burner (v), the power input (w), the u. v. emission (Cd), the total intensity (Th. C.) during the first thirty-five minutes after lighting the burner.

follows the behavior of the potential across the arc. No difference between new and used burners exists in this respect. It is obvious, therefore, that any control instrument built into an apparatus of the type used here should register the potential between one anode and the cathode. This would at least permit the operator to judge when the electrical equilibrium has been reached; but no conclusions as to the ultraviolet radiation emitted may be drawn.

A total of five burners was examined with the methods described above; the results are compiled for one burner (71241) (Table I). Column I gives the age in hours (A), Column II, the power input in watts (W), Column III, the deflection of the galvanometer connected to the photoelectric cell (Cd), Column IV, the time in minutes and seconds for the photochemical reaction (K), and Column V, the ratio between the galvanometer deflections when the

Table I
BURNER 71241

A	W	Cd	K	Q / S1
0	196	10.5	2.3	1.53
25	192	11.0	...	1.46
50	192	10.0	3.0	1.41
100	189	8.5	3.3	1.43
150	185	7.0	3.7	1.40
200	194	7.5	3.25	1.42
250	194	7.0	4.0	1.38
300	196	6.0	4.75	1.12
400	190	7.0	4.3	1.11
500	184	5.0	5.0	0.99
600	190	7.0	5.75	1.14
700	194	6.0	6.3	1.17
800	184	4.5	7.5	1.04
900	174	3.5	8.2	0.89
1000	184	3.5	9.8	0.8
1100	179	3.5	9.4	0.81
1200	191	3.0	12.5	0.9

Table II

	75257			36627			77191			79940		
A	W	Cd	K	W	Cd	K	W	Cd	K	W	Cd	K
0	192	10.5	2.6	190	10.0	2.45	...	...	....	180	10.5	2.75
50	195	11.0	2.75	194	9.0	3.0	...	...	....	...	....	....
100	200	8.0	3.0	194	7.5	3.25	...	...	....	184	9.0	2.50
150	180	7.0	3.50	196	6.0	3.0	...	...	....	180	9.0	2.75
200	180	5.5	5.0	180	7.0	3.0	...	...	....	...	....	....
250	180	6.5	4.0	188	6.0	3.50	194	6.0	3.0	...	....	....
300	176	7.0	4.50	170	7.5	3.25	176	5.0	4.0	190	6.0	3.75
400	190	7.0	4.50	189	7.5	4.0	176	6.0	3.25	...	....	....
500	...	....	....	180	7.0	....	189	5.5	5.0	....	....	....
600	...	....	....	184	5.0	4.0	188	4.0	7.0	196	6.5	5.25
700	...	....	....	190	7.0	4.0	184	4.5	6.0	...	....	....
800	...	....	....	192	6.3	5.50	178	4.0	5.50	186	5.5	6.50
900	...	....	....	...	...	....	180	3.0	7.25	188	3.5	....

thermocouple was placed under the mercury vapor lamp and under the undervolted electric bulb which served as a standard $\left(\frac{Q}{ST}\right)$. The latter figure is proportional to the total radiation of the lamp. In each instance skin tests on the same part of the body of several adults were carried out

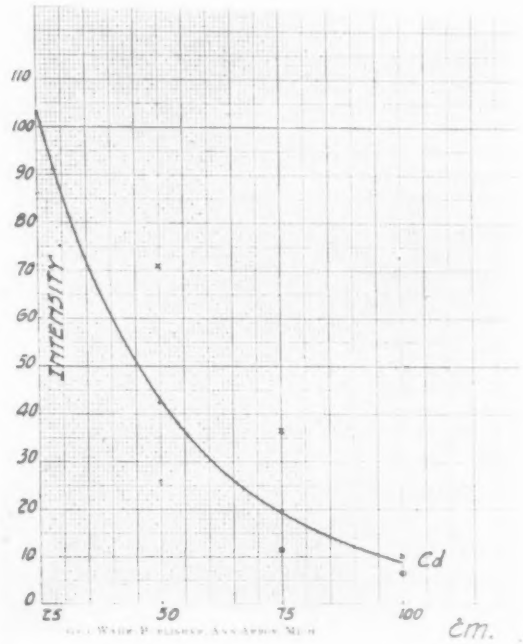

FIG. 3. The changes of the intensity of radiation with the distance from the burner. x = photochemical test; . = cadmium cell; o = calculated by inverse square law.

in order to check the results of the measurements on the biological object. The figures obtained from four other burners will be found in Table II. The reaction time of the Keller test is corrected to 25° C. because like all photochemical reactions, it is dependent upon the temperature. Table III gives comparative data on the lines 3130, 3022, 2967, 2897, 2804, 2650, and 2536 Å, over a period of twelve hundred hours. The intensity of line 3130 was set equal to one hundred. The last column of Table III gives the relative sensitivity (F) of the cadmium cell for each line, while the last horizontal line represents the reading of the photoelectric cell when exposed to the burner. It seems that the relative intensity of 2804, 2650, and 2536 Å drops more than that of the other lines. The percentage of error in these measurements is higher for the lines of low intensity because the galvanometer deflection amounted to only 3 mm. or less. The variations in intensity with the distance from the burner were also studied. From Curve Cd in Figure 3, it appears that the

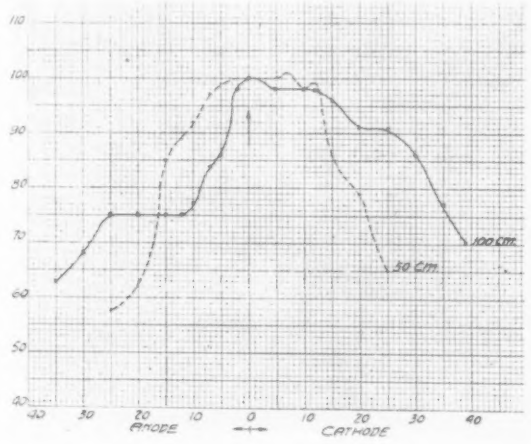

FIG. 4. Total intensity parallel to the burner axis at 50 and 100 cm. distance.

measured intensity of the ultraviolet region recorded by the cadmium cell is not identical with the intensity calculated by means

TABLE III

Line	New Burner	After 300 Hrs. Use	After 600 Hrs. Use	After 900 Hrs. Use	After 1200 Hrs. Use	F
3130	100	100	100	100	100	20
3022	32	29	28	25	29	40
2967	21	18	20	18	12	80
2897	6	6	4	6	6	138
2804	6	6	4	3	0	240
2650	12	12	10	7	6	138
2536	15	6	6	7	6	36
Cd	11.5	7.5	6.5	5.5	3.0	

of the inverse square law. The photochemical test brings this fact out still more strikingly. The calculated and measured values approach each other with increasing distance. Aside from the fact that the burner is not a point source of light, the presence of reflected radiation from the hood explains this observation. Figure 4 demonstrates the distribution of the inten-

sity at 50 and 100 cm. distance from the burner parallel to its axis, taken with the thermocouple and, therefore, showing the variation of the total output. There was no essential difference between new and used burners. The distribution of the total emission in a plane vertical to the axis is given in Figure 5.

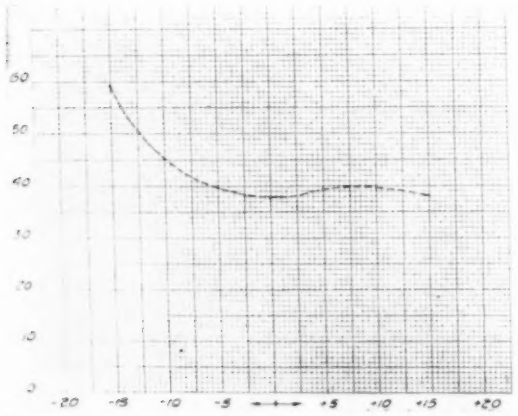

Fig. 5. Intensity perpendicular to the burner axis at 50 cm. distance taken with the thermocouple.

In order to compare the response of the cadmium cell and the photochemical test with that of the skin, a number of experiments with normal and increased potential on new and old burners were performed. The ultraviolet emission of a new burner for which the average erythema time amounted always to about three minutes was measured with a cadmium cell; other burners were then calibrated on that basis, with a cadmium cell and photochemical test for 50 and 100 cm. distance. Graded exposures of symmetrical parts of the body were checked against the three-minute exposure of a new burner as standard. Since small fields were used as closely side by side as possible, it was relatively simple to select the corresponding reactions without introducing the individual variation.* Tables IV and V show the results.

All these comparative measurements carried out during the past two years have led to the belief that the cadmium photoelectric cell represents today the most simple and reliable device suitable for our purposes.* While the figures obtained were useful in our own laboratory, it seemed advisable to develop some method of calibration which would make the results reproducible. Dorno's sensitivity curve[9, 10] showing a maximum at about 2800 Å which we have redetermined (Fig. 6, Curve 1) suggests the use of the line 2804 Å for the standardization of the cadmium cell. If the cell is to be used for measuring a range of the ultraviolet spectrum, then, in order to make such a calibration valid, this single line, and all other lines included in this range, should change their intensity with varying potential across the arc or with age of the burner in approximately the same ratio. A study of this question satisfied us that this is the case. As demonstrated in Figure 7, stepping up the secondary potential 25 per cent increased the power input about 30 per cent; the intensity of the examined lines 2.5 times (mean value), and the deflection of the galvanometer connected to the photoelectric cell 2.5 times; decreasing the primary potential by 10 per cent decreased the power input

Table IV

Burner	Cd	K	Skin
New	10.0	3.0	3
Old	3.0	12.5	9
$\frac{N}{O}$	3.3	4.2	3

Column II gives the deflection of the galvanometer connected to the photoelectric cell (Cd). Column III gives the time of the photochemical reaction in minutes (K). The last column gives the time of exposure of the skin. The quotient $\frac{N}{O}$ expresses the ratio between the new and old burner. Number of cases: 11.

Table V

V*	Cd†	K‡	Exposure§	Reaction after 6 Hrs.
126	8.5	4.2	4.0	+
158	20.0	2.0	2.0	++
Ratio	2.36	1.45	2.0	over 2.0

* Potential across the arc.
† Deflection of galvanometer of the photoelectric cell.
‡ Time for photochemical test in minutes.
§ Time of exposure in minutes at 50 cm. distance. Number of cases: 7.

* In some tests the tintometer method of Schall and Alius (*Strahlentherapie*, 1925, xix, 796) with their original dye solutions was used.

* Another device has been developed recently by Rajewski.[11] He takes advantage of the ionization in a small air chamber due mainly to photoelectrons emitted by a cadmium electrode during exposure to a mercury vapor lamp. The cell window is made of quartz and transmits, therefore, ultraviolet radiation below 2500 A. We have built a similar chamber of this type which can be connected to most of the roentgen-ray dosimeters on the market. Our preliminary measurements have shown that it will be necessary to adapt the sensitivity curve of the ionization chamber to the erythema curve of the skin.

16 per cent, the secondary potential 12 per cent, the intensity of the examined lines to about one-half, and the photoelectric cell reading to one-half (Fig. 8). It was interesting to note that the total emission was increased relatively less at higher potential than the ultraviolet part of the spectrum as recorded by the cadmium

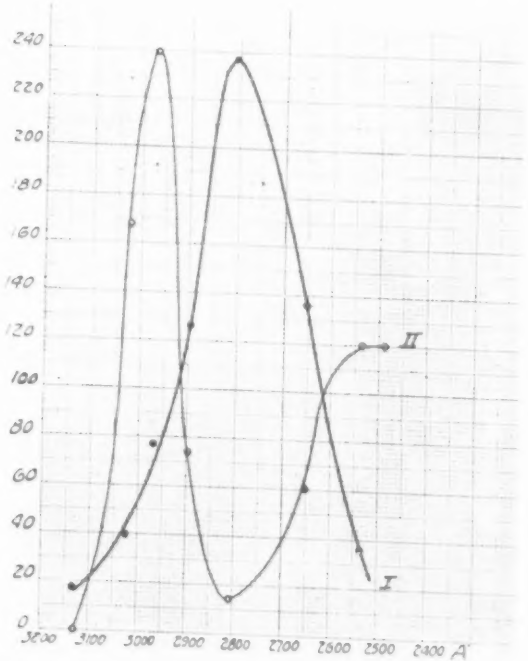

FIG. 6. Sensitivity curve of the Cd photoelectric cell (I) and of the skin (II).

cell, while the opposite held true for the figures obtained with decreased potential.

Table III and Figures 7 and 8 show that the relative intensities of all the lines in the region vary sufficiently alike so that the reaction of the cell to 2804 Å may be used to standardize the cell. This wave length is chosen because it is the only line which gives a satisfactory response both with the cell and with a thermopile. The following procedure was worked out. A thermopile was calibrated by means of a standard source of radiation (Bureau of Standards) which permitted the measuring of the absolute intensity of the line 2804 Å. Then the cadmium cell was placed in the identical position in the focal plane of the spectrograph, the width of the slit being the same as that of the thermocouple and permitting only the one line to pass. The cell current was then measured by a calibrated galvanometer. Thus the current released in the cell by 1 erg/sec. of radiation of line 2804 Å was determined. In this experiment, the standard source of radiation emitting 8.1 erg/sec./cm.^{2} at one meter distance gave a galvanometer

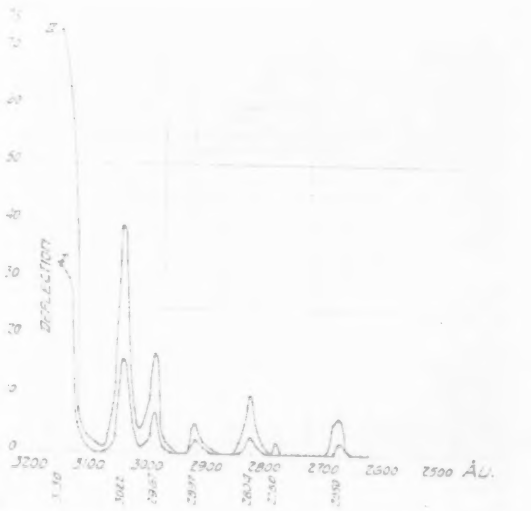

FIG. 7. The relative intensity of the ultraviolet lines between 3130 and 2536 Å at normal (I) and at increased potential (II).

deflection of 44 mm. when falling on the thermopile slit of an area of 0.65 by 16.5 mm. at a distance of one meter. The line 2804 Å of the mercury vapor lamp spectrum gave a deflection of 5 mm. corresponding to 0.099 erg/sec. The same line falling on the cadmium cell gave a galvanometer deflection of 23 mm. or released a photoelectric current of 27.6×10^{-11} amperes.* When the cell was placed at 50 cm. distance measured from the center of the burner to the cadmium film, a photoelectric current of 68.9×10^{-9} amperes was recorded. The slit opening was 1.0×2.5 cm.^{2}, 8 cm. above the cadmium surface and with its shorter axis parallel to the burner. The latter had been in operation for about two hundred hours. An exposure of three and one-half minutes at 50 cm. distance produced a medium erythema on adult human skin. These data serve as basis for the calibration of the cadmium cell.

*The same method serves as a control of the sensitivity of an individual cell.

IV. DISCUSSION OF RESULTS

A study of Tables I and II demonstrates the fact that the output of the quartz mercury vapor burner (vacuum A.C. type) decreases rapidly during the first two hundred to three hundred hours of use, in the region below 3100 Å. The figures obtained by means of the cadmium cell

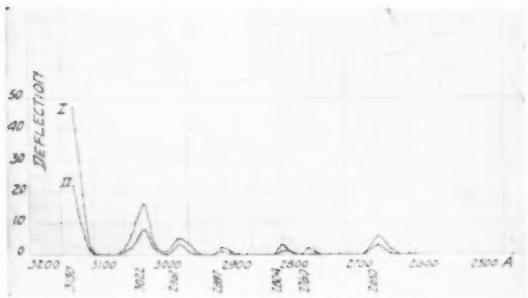

FIG. 8. The relative intensity of the ultraviolet lines between 3130 and 2536 Å at normal (I) and decreased potential (II).

and the photochemical test show fair agreement with the skin reaction. The rate of "aging" then decreases, and after nine hundred to twelve hundred hours, replacement of the burner is usually indicated, since the treatment time is too long for economical work because the emission of short ultraviolet rays is greatly diminished. The photochemical test and the photoelectric cell readings do not always run exactly parallel. The emission of the old burner is recorded lower than it is in reality by the photochemical test. This is undoubtedly due in part to the limitations of any photochemical method.* It is apparent that the test becomes more inaccurate with increasing reaction time, if checked by the skin erythema. The latter observation may be made by decreasing intensity through increasing the distance or by using an old burner. It therefore cannot be entirely explained by the statement of Schneider and Sperti[12] that the decomposition of KI seems to be influenced only by radiation below 3600 Å and responds best to short ultraviolet rays.

The comparison of the photochemical, photoelectric, and skin effect offers some interesting deductions as illustrated in Tables IV and V. From the quotients calculated representing the ratio of new and old burners $\left(\frac{N}{O}\right)$, it is evident that the cadmium cell reading shows fair agreement with the skin reaction, while the photochemical test gives lower values of the ultraviolet intensity (see Table IV). A similar observation has been made when stepping up the potential (see Table V). The cadmium cell indicates an increase in the ultraviolet part of the spectrum of 2.36 times, the photochemical test only 1.45 times. Skin areas exposed four and two minutes respectively showed a definitely stronger erythema in the field irradiated two minutes with the burner running at high potential. This brings the ratio of skin reaction and photoelectric cell reading in close agreement.

The fact that the inverse square law does not hold for this type of lamp (Fig. 3) makes it inadvisable to calculate the doses at various distances using as initial value the dose known for one distance, particularly if this is below 50 cm. While the decrease of the total intensity as measured by a thermopile follows rather closely the inverse square law at distances more than 50 cm., this is not the case for the short ultraviolet region. It is certain, however, that the difference between the calculated and measured figures, as given by the photochemical test, are exaggerated. It is partly due to the fact that double the distance is used in treatments as during the test. Experiments on the skin have brought this out convincingly. All these observations make advisable the measurement of the intensity for each burner, potential, and treatment distance separately, at least in clinical investigations.

The energy distribution parallel to the axis of the burner at different distances gives definite information regarding the homogeneous exposure of the human body (Figs. 4 and 5). At 50 cm. burner skin distance, a part of 40 cm. length receives a sufficiently even dose; for 100 cm. burner skin distance, the isodose area extends to almost 70 cm. if burner and body axis are parallel (Fig. 4). This allows for a variation in the reaction of ± 15 per cent. Guthmann[13] obtained similar results. When

* A review of most of these tests is given in Mayer, E., "Clinical Application of Sunlight and Artificial Radiation." Baltimore, 1926, Chapter XIV.

the photoelectric cell was used for these measurements, the readings taken under the cathode part* of the burner seemed to show more ultraviolet rays of short wave length than the remaining part of the arc, as high as 30 per cent more than the center. The total intensity does not show, however, such high fluctuations under the same measuring conditions. Again it can be stated that new and used burners behave alike. By reversing the position of the cell and, therefore, changing the part of the cadmium film exposed to the light, it became evident that different parts of the cadmium layer give a different emission. The cell must be left in exactly the same position in order to get comparable results. The intensity change perpendicular to the burner axis is much smaller in total emission as measured by the thermocouple (Fig. 5). Assuming a diameter of 30–40 cm. between the axillae as average, an even dose would be delivered at 50 cm. burner skin distance. All these calculations do not take into consideration the varying sensitivity of the skin in different parts of the human body.

An attempt to establish a physical dose unit and to correlate that unit with the biological effect encounters serious difficulties. A number of investigators have offered suggestions, for instance, Eidinow,[14] Hill and Eidinow,[15] Griffith and Taylor,[16,17] Coblentz,[18] Schultz,[19] and Anderson and Robinson.[20] Hill and Eidinow worked out a unit (1K) based on the killing effect of short ultraviolet rays on Paramecium. Three 1K units produced a definite erythema in the majority of cases. Griffith and Taylor adopted an arbitrary unit corresponding to the drop of their electroscope connected to the quartz cadmium cell in a given time. This quartz cell transmits, however, ultraviolet rays below 2500 Å and must therefore read different values than those corresponding to the skin effect. On the other hand, the cadmium cell in uviol glass has its maximum at 2800 Å, which is lower than the skin maximum at about 3000 Å. According to Hausser's[21] latest publication, there is a second maximum for the skin erythema at 2536 Å (Fig. 2, Curve II). In that case the sensitivity curve of the cadmium cell should run almost parallel to that of the skin. An objection voiced by Rüttenauer[22] does not concern us in this investigation; he requests the spectral energy curve in addition to the cadmium cell reading if different sources of light are to be compared. Coblentz and Schultz selected an absolute unit, i.e., the gram calorie per centimeter^2 per minute. Coblentz suggests 0.01 gram calorie per square centimeter per minute of the radiation of that part of the sun spectrum obstructed by window glass. According to Schultz, 0.08 gram calorie per square centimeter corresponds to a medium erythema dose. Anderson and Robinson have incorporated an absolute unit in a photochemical reaction; they measured the decomposition of an oxalic acid solution for a number of wave lengths in the ultraviolet region, the absolute energy of which was defined in erg per second. Anderson and Gordon[23] recently designed a fluorescent ultraviolet photometer which measures the quality of ultraviolet radiation in various parts of the spectrum by using filters. It has been calibrated by the authors in ergs, and a calibration chart is furnished with each instrument.

There is no doubt that none of these methods is ideal. The units are chosen at will, and although they serve the purpose well in the laboratory where they have been developed, no general comparison of results is possible on that basis. Photochemical reactions are either inaccurate or too complicated. They can, of course, be perfected in a scientific laboratory (see, for instance, Field and Baas-Becking)[24] but they are not so satisfactory in practice. It must be admitted also that the cadmium cell is not perfect, but it undoubtedly offers the best possibilities at the present time. Its calibration can be carried out, and for practical purposes a simple unit making use of an amplification circuit has been constructed by Huxford and one of us.[2] The correlation between the recorded energy and the biological effect is easily established. The degree of ery-

* Some observers (Koeppe and Lauber, *Arch. f. Kinderheilk.*, 1928, lxxxiv, 1) found more emission under the anode; they used, however, a different method, namely, the degree of hemolysis in an erythrocyte solution. Schall and Alius (*Strahlentherapie*, 1927, xxvi, 651), on the other hand, measured a higher intensity under the cathode.

thema should be left to the individual clinician. There is no doubt that very few agree on the conception of a skin tolerance dose. For statistical purposes a mean value can be instituted based on a large number of cases as has been done at the University Hospital in Ann Arbor. The energy measured by a certain deflection of a galvanometer connected to the calibrated cadmium cell and corresponding to a known quantity of electricity may be called one ultraviolet unit provided it will produce a mild erythema on normal adult human skin. We defined this dose by the following factors:*

Burner-cadmium film distance	50 cm.
Cell window (short axis parallel to burner)	1.0 × 2.5 cm.²
(8 cm. above cadmium surface and under center of burner)	
Released photoelectric quantity in the cell (equivalent to the ultraviolet unit) the same as that quantity released by 6000 erg of $\lambda = 2804$ Å.	

This renders the dose reproducible and permits the calibration of other cadmium photoelectric cells in this unit. The figures given for the so-called erythema dose should be regarded as a "statistical mean value" in analogy to the same procedure in roentgen-ray therapy (Pohle and Barnes[25]).

V. SUMMARY

(1) A study has been made of the spectral energy characteristics of the mercury vapor lamp. A vacuum type burner run at 110 volts A.C. was used in all investigations. Measurements of the variation of the relative intensity of the lines, 3130, 3022, 2967, 2897, 2804, 2650, and 2536 Å under varying conditions, i.e., age of burner and operation are reported.

(2) The ultraviolet emission has also been measured by a cadmium photoelectric cell in uviol glass, by the starch iodine test, and by the skin erythema. It may be concluded from these investigations that the cadmium cell gives a satisfactory reading of the erythema producing ultraviolet part of the mercury vapor spectrum.

(3) A method is proposed by which the calibration of a photoelectric cell in absolute units can be carried out. This permits checking the sensitivity of an individual cell and calibrating other cadmium cells in the same units. The correlation between this absolute unit and the biological effect (skin erythema) has been established.

* For detailed data see page 343.

REFERENCES

1. Pohle, E. A. Physical and biological problems in heliotherapy. I. Standardization of ultraviolet lamps for clinical use. Am. J. Roentgenol. & Rad. Therapy, 1926, xv, 193–201.
2. Pohle, E. A., and Huxford, W. S. Physical and biological problems in heliotherapy. II. A measuring device for ultraviolet radiation. Am. J. Roentgenol. & Rad. Therapy, February, 1928, xix, 144–150.
3. Prince, D. C., and Vogdes, F. B. Principles of Mercury Arc Rectifiers and Their Circuits, New York City, 1927.
4. Bering, F., and Meyer, H. Methoden zur Messung der Wirksamheit violetter und ultravioletter Strahlenquellen. *Strahlentherapie*, 1912, i, 189–207.
5. Keller, P. Über die Wirkung des ultravioletten Lichtes auf die Haut unter besonderer Berücksichtigung der Dosierung. *Strahlentherapie*, 1923, xvi, 52–74; 1924, xvi, 301; 1924, xvi, 537–553; 1924, xvi, 824–835; 1924, xvii, 197–208.
6. Schall, L., and Alius, J. H. Zur Biologie des Ultraviolettlichts. I. Zur Frage des Dosimetrie des Ultraviolettlichts. *Strahlentherapie*, 1925, xix, 559.
7. Hörnicke, C. B. Die Änderungen von Intensität und Stromverbrauch verschiedener Bestrahlungslampen, speziell der Quecksilberdampflampe während der Einlaufzeit. *Strahlentherapie*, 1925, xx, 664–672.
8. Harrison, G. R., and Forbes, G. S. Spectral energy characteristics of the mercury vapor lamp. *J. Optic. Soc., America*, 1925, x, 1.
9. Dorno, C. Über ultraviolette Strahlung. *Strahlentherapie*, 1922, xiv, 25–37.
10. Dorno, C. Zum Gebrauch der Cadmiumzelle für Messungen der ultravioletten Strahlung. *Strahlentherapie*, 1927, xxv, 351–352.
11. Rajewsky, B. Ein praktisches Messgerät zur Dosierung der ultravioletten Strahlen. *Strahlentherapie*, 1928, xxix, 180–189.
12. Schneider, H., and Sperti, G. The quantum theory in biology. *University of Cincinnati, Institute of Industrial Research*, April, 1926, Series 4, Paper 1.
13. Guthmann, H. Physikalische Grundlagen der Lichttherapie, Berlin, 1927.
14. Eidinow, A. Some observations on the dosage of ultra-violet rays in artificial sun treatment. *Lancet*, 1925, ii, 317–323.
15. Hill, L., and Eidinow, A. The practical methods of dosage of ultraviolet rays. *Practitioner*, 1925, cxv, 102–111.
16. Griffith, H. D., and Taylor, J. S. The photometry of therapeutic lamps. An instrument for measuring ultraviolet radiation, and some applications of therapeutic interest. *Lancet*, 1925, ii, 1205–1207.
17. Griffith, H. D., and Taylor, J. S. The photometry of therapeutic lamps. I. Relation of photoelectric power of lamps to their bactericidal power. II. Comparison of emission of various ultraviolet sources. *J. Hyg.*, 1926, xxv, 218–224.
18. Coblentz, W. W. Spectral characteristics of light

sources and window materials used in therapy. (Paper presented before the Twenty-first Annual Convention of the Illuminating Engineering Society, Chicago, Ill., October, 1927.)
19. Schultz, P. A. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1924, xxxii, 2 Kongress, 33.
20. Anderson, Wm. T., Jr., and Robinson, F. The oxalic acid-uranyl sulfate ultraviolet radiometer. *J. Am. Chem. Soc.*, 1925, xlvii, 718.
21. Hausser, K. W. Einfluss der Wellenlänge in der Strahlenbiologie. *Strahlentherapie*, 1928, xxviii, 25–44.
22. Rüttenauer, A. Über ultraviolette Messungen mittels Cadmiumzelle und Elektrometer. *Strahlentherapie*, 1928, xxvii, 794.
23. Anderson, Wm. T., and Gordon, E. A fluorescent ultraviolet photometer. *J. Optic. Soc., America*, 1928, xvi, 224.
24. Field, J., Jr., and Baas-Becking, L. G. M. Light titrations. 1. The starch-iodine reaction. *J. General Physiol.*, 1926, ix, 445–450.
25. Pohle, E. A., and Barnes, J. M. Clinical and physical investigations of the problem of dosimetry in roentgen therapy. *Radiology*, April, 1928, x, 300–317.

DISCUSSION

Dr. P. M. Hickey, Ann Arbor, Mich. I think this paper reminds us of a presentation that was made at the time Mr. Snook brought forth the milliammeter. We were accustomed to turn our tubes on, and guess at the results. Then when Mr. Snook came along and told us we could use the milliammeter, we began to get the idea of the energy output of our tubes.

So I think the introduction of this measuring device which Dr. Pohle has just described marks an era in the use of ultraviolet radiation because without some means of measuring and comparing the output of these different lamps, the clinician has to go purely by rule of thumb. This instrument gives a means of comparison of different mercury vapor lamps and the comparison of the efficiency of one particular lamp during different periods of activity. I therefore think it marks a very important step in the standardization of the ultraviolet dose.

Prof. Ralph A. Sawyer, Ann Arbor, Mich. I want to make a few comments on this paper from the point of view of a physicist. There are one or two things with regard to the use of the cadmium cell for the calibration of the quartz mercury vapor lamp which, I believe, should be mentioned. I would like to say that the cadmium cell in the uviol glass has been used for many years by Dorno for the measurement of the intensity of the ultraviolet radiation from the sun. In the use of the cadmium cell for the measurement of the output of the quartz mercury vapor lamp, a different problem arises. The mercury vapor lamp, in contrast to the sun, emits a discontinuous spectrum, while the sun emits a continuous spectrum; the lamp also emits varying wave lengths which vary considerably in intensity under different conditions of emission.

The question we have to ask ourselves is whether or not under the conditions of emissions which we meet in the clinical use of the lamp, the various lines which it emits will vary in intensity all in the same way, since the cadmium cell is exceedingly selective to wave length in its response.

Our measurements show, which I, myself, did not expect, that the various lines in the erythema producing region of the spectrum all behave in nearly enough the same way under the varying conditions of age of the burner and operating conditions so that it is perfectly safe to use the cadmium cell to measure the ultraviolet output of the lamp. The cadmium cell does certainly rate the ultraviolet output of the quartz lamp in some sort of unit.

The question then arises whether that unit is a unit which is proportional to the erythema producing ultraviolet dose, a thing we all want to know. The cadmium cell is very selective to wave length, and the skin is also very selective in its receptiveness to the ultraviolet wave length.

The two curves which we see in Figure 6 are certainly very similar. They do not coincide. There is another point, and that is with varying intensity of light, the response of the cadmium cell is proportional to intensity throughout the wave length range while, if we can believe the recent work of Hausser and Vahle, the response of the skin to varying intensities of light for different wave lengths, while the response is proportional to the intensity, the proportionality factor is very different for different wave lengths. That means I think, that it is impossible to hope for any measuring device which will give us precisely the response of the skin to ultraviolet radiation. The only answer as to whether a certain device is suitable or not is the clinical answer, and I hope it will please you to hear a mere physicist, who is interested in measurements, say that.

I think that the clinical measurements Dr. Pohle has carried out in the hospital over a period of years show that the cadmium cell with the uviol glass bulb is a perfectly satisfactory device for measuring the ultraviolet erythema producing efficiency of the mercury vapor lamp in quartz glass.

There is just one other thing to say, the question of the absolute rating of the lamp. The method of rating the lamp in absolute units which we have introduced here depends on the permanence and reproducibility of the cell. I think there is no question of the permanence of the cell if not abused. As to its reproducibility, we have repeated in our laboratory the

curves of the sensitivity of the cell and checked precisely the curves which have been given by Dorno and also by other investigators.

Absolute measurements of the kind we have made here are difficult and can be made only in a precision laboratory. The use of the cadmium cell itself, I believe, is almost foolproof. No filters are required and no chemical manipulation is necessary.

When you have a calibrated cell set up in its circuit, it comes down to the reading of one instrument, which can be done in a couple of minutes, and I should like to point out just one thing about the need of rating such a lamp.

Our measurements show that a variation of 1 per cent in the input voltage on one of these lamps causes a variation of 5 per cent in the ultraviolet output. If any of you, who have to deal with commercial city circuits, will put a voltmeter on a circuit, you will quickly find, unless you are exceptionally fortunate, that the voltage variation with which you have to deal may be as much as 5 per cent, or even 10 per cent under certain conditions, meaning a variation of the ultraviolet output of your lamp of 50 per cent, to say nothing of the rapid depreciation with age which must be continually checked.

SOME RESULTS OF A STUDY OF ROENTGENOGRAMS OF THE ABDOMINAL VISCERA*

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SOME of the results of a roentgenological study of the normal form, position and topography of the abdominal viscera in healthy young adults were presented at the International Congress of Radiology in London three years ago. In that paper the stomach and colon were discussed. In this paper the results of the study of the liver and spleen will be presented.

Roentgenoscopic studies and roentgenograms have been made of 1200 healthy students at the University of California, the number of males and females being equal.

Most of the roentgenograms were taken with the subject erect, in the anatomical position, but several hundred were taken with the subject erect and prone and a smaller number with the subject erect and supine.

The target was centered on the interiliac line, a line drawn between the highest points of the iliac crests,[1] except in taking the roentgenograms to show the effects of exercise and of blood transfusion on the size of the spleen when it was centered over the spleen. With the subjects in the anatomical position the target film distance was 90 cm. With the subjects prone and supine, a Bucky diaphragm was used and the target film distance was 72.5 cm.

Roentgenologists appreciate the fact that sharp definition of the upper end of the spleen, its posterior border and its anterior border between the gastric and renal surfaces are not often obtained in roentgenograms. Therefore allowance must be made for a small probable error in the measurements of the length and the width of the spleen shadow.

From the variations found in the form and size of the liver, in dissecting material, it has been correctly inferred that there is a similar variation in its form and size in the living. Figures 1 and 2 show some of the variations found in the dissecting material. In Figure 1 the third liver in the middle row is a form commonly seen in roentgenograms of the living. Short livers like those at the right of the first row and at the left of the third row may have the form of the His model, which is not common.

The greatest length of the right lobe

* Presented at the Second International Congress of Radiology, Stockholm, Sweden, July 23–27, 1928.

FIG. 1. Ventral view of livers found in dissecting material showing variations in size and form.

of the liver as shown in roentgenograms of the healthy young adults, subject erect, varies from 15.5 to 25.5 cm. The average length is 21.1 cm. in males and 20.3 cm. in females. This nearly agrees with the results of Pfahler[1] who gives the average length as 21.4 cm. in males and 21.2 cm. in females.

The per cent tabulation given in Figure 3 shows that with the subject erect the most frequent length of the right lobe of the liver in males is between 21.0 and 21.9 cm. It is this length in 21.6 per cent of the subjects. The most frequent length in females is between 20.0 and 20.9 cm. It is this length in 18.5 per cent of the subjects.

These results demonstrate that there is marked difference in the length of livers due to sex. More males than females have long livers. This is contrary to the findings of Pfahler[2] who says that sex makes no appreciable difference in the length of the liver. His conclusion is based on a comparison of averages. Comparisons based on averages are misleading.

The relation of the lower tip of the liver to the brim of the pelvis was determined by measuring its distance above or below the interiliac line. The lower tip of the liver, in healthy young adults in the anatomical position, occurs below the interiliac line in 50.2 per cent of males and 34.0 per cent of females. This gives a new picture of the position and relations of the caudal tip of the liver.

In both sexes, subject erect, the zone of most frequent occurrence of the lower tip of the liver is upper zone one between 0 and 2.5 cm. above the interiliac line. It occurs here in 39.6 per cent of the males and in 42.8 per cent of the females. It occurs in upper zone three in 2.4 per cent of the males and in 4.8 per cent of the females. It is found in lower zone one, 0

FIG. 2. Dorsal view of livers found in dissecting material showing variations in size and form.

to 2.5 cm. below the interiliac line in 38.9 per cent of the males and 27.9 per cent of the females. In 11.3 per cent of the males and 6.1 per cent of the females, it occurs below this zone.

These results demonstrate that with the subject erect, long livers with their lower tips extending as much as 5 cm. below the interiliac line into the pelvic cavity are normal. They also give further evidence that more men than women have long livers.

The liver usually moves upward when the subject changes from the erect to the supine position. This movement is called the excursion. The extent of the excursion is determined during the roentgenoscopic examination in the following manner. In each of the positions, erect and supine, the position of the lower tip of the liver is marked on the body of the subject, and the distance between these marks is measured. The length of the excursion varies from 0 to 9.0 cm. in males and from 0 to 10.9 cm. in females. There is no excursion of the liver in 26 males and 19 females. In both sexes the most common excursion is between 2.0 and 2.9 cm. It is 3.0 cm. or more in 53.7 per cent of males and 57.0 per cent of females and 5.0 cm. or more in 19.3 per cent of males and 25.8 per cent of females. A long excursion is more common in females than in males.

This excursion makes a decided change in the per cent relation of the occurrence of the lower tip of the liver in the different zones. The position of the lower tip of the liver with the subject supine is obtained by combining the distance of the tip from the interiliac line, subject erect, with the excursion of the tip. With the subject supine the range of occurrence of the lower tip of the liver is from 14.9 cm. above the interiliac line to 4.2 cm. below the line. The zone of its most frequent occurrence in males is the same as with the subject

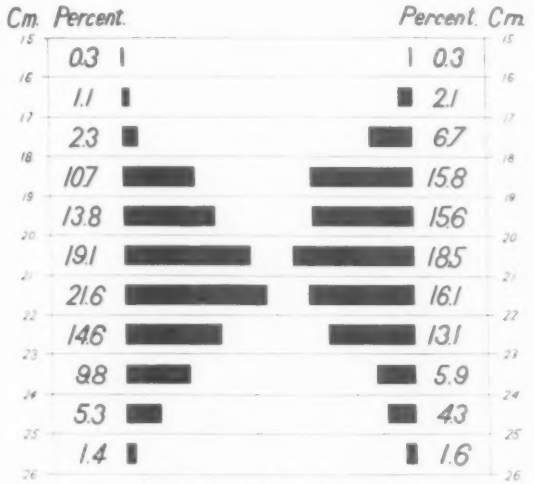

Fig. 3. Length of the right lobe of the liver and its per cent occurrence in centimeter zones, in 356 males and 373 females, subject erect.

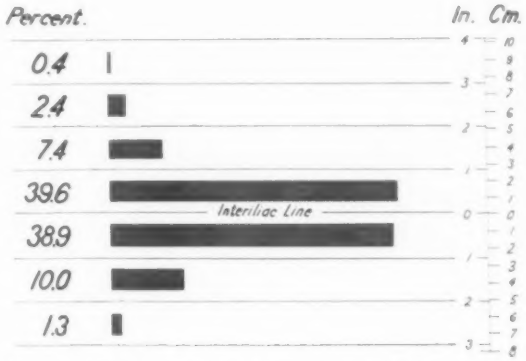

Fig. 4. Relation of the lower tip of the liver to the interiliac line in 460 males, subject erect. In this chart and similar charts, each space above the line and below the line represents a zone of 2.5 cm. Zones above the line are called upper zones and those below the line are called lower zones.

Fig. 5. Relation of the lower tip of the liver to the interiliac line in 423 females, subject erect.

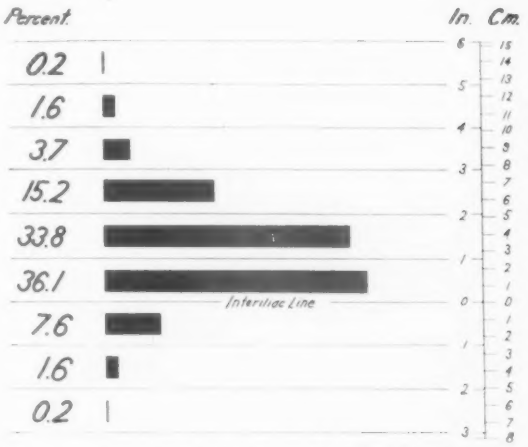

Fig. 6. Relation of the lower tip of the liver to the interiliac line in 432 males, subject supine.

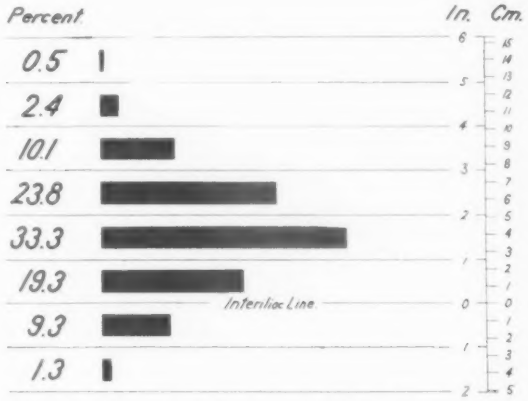

Fig. 7. Relation of the lower tip of the liver to the interiliac line in 378 females, subject supine.

erect, upper zone one, where it occurs in 36.1 per cent of the subjects. In 69.9 per cent it is in upper zones one and two, between 0 and 5.0 cm., above the line. It is below the line in 9.4 per cent of these subjects. In females with the subject supine the zone of most common occurrence of the lower tip of the liver is upper zone two, where it occurs in 33.3 per cent of the subjects. It is below the line in 10.6 per cent of these subjects.

As is true with the subject erect, so it is with the subject supine, long livers with their lower tip 5.0 cm. below the interiliac line are normal.

Although the enlarged spleen and its significance are frequently considered in literature, except in textbooks no statement was found of its normal size in

Fig. 8. To show variations in size and form of the spleens found in dissecting material.

man. These books say that its size is more variable than that of any other organ of the body, and that it enlarges during digestion. According to Gross[3] the spleen gradually atrophies from youth to old age. Some of the variations in the size and shape of the spleen as it is found in dissecting material are shown in Figure 8.

With the subject erect, the length of the spleen in the healthy young adult males varies from 9.0 to 17.0 cm. and in females from 7.0 to 16.0 cm. The most common length of the spleen in healthy young males is between 12.0 and 12.9 cm. (Fig. 9). It is this length in 28 per cent of the subjects. Its most common length in healthy young adult females is between 11.0 and 11.9 cm. where it is this length in 25.4 per cent of the subjects. Its length is more than 12.9 cm. in 51.0 per cent of the males and 25.1 per cent of the females, and less than 11.0 cm. in 8.6 per cent of the males and in 28.9 per cent of the females. These results demonstrate that sex is a factor affecting the length of the spleen and that more males than females have long spleens.

The relation of the caudal end of the spleen to the interiliac line is also of interest. With the subject erect, the zone of most frequent occurrence of the caudal end of the spleen in males is upper zone three, 5.1 to 7.5 cm. above the interiliac line where it occurs in 42.1 per cent of the subjects. It is found more than 7.5 cm. above the interiliac line in 25.0 per cent

Centimeters	Males %	Females %
7.0–7.9	0.0	0.4
8.0–8.9	0.0	1.7
9.0–9.9	1.2	5.6
10.0–10.9	7.4	21.2
11.0–11.9	14.5	25.4
12.0–12.9	28.0	20.0
13.0–13.9	22.4	17.3
14.0–14.9	14.5	3.1
15.0–15.9	7.9	3.9
16.0–16.9	2.2	0.4
17.0–17.9	4.0	0.2
18.0–18.9	0.0	0.2

FIG. 9. Length of spleen and per cent of its occurrence in centimeter zones in 392 males and 409 females, subject erect.

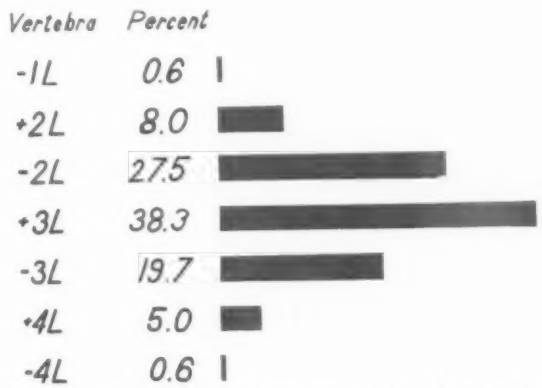

FIG. 10. Relation of the lower end of the spleen to the upper (+) and lower (−) halves of the lumbar vertebrae in 298 males, subject erect.

of the subjects and less than 5.1 cm. above the line in 32.1 per cent.

In females, subject erect, the zone of most frequent occurrence of the caudal

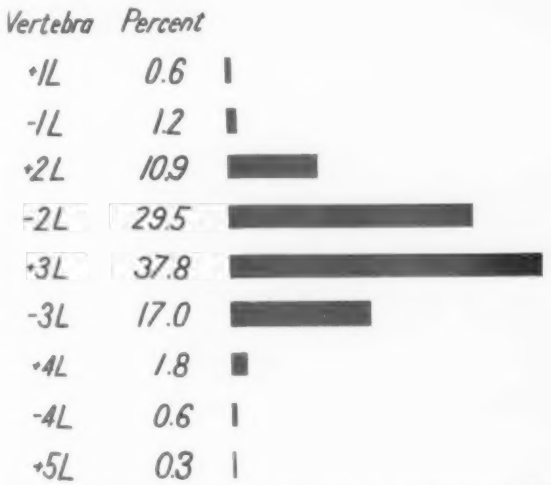

FIG. 11. Relation of the lower end of the spleen to the upper (+) and lower (−) halves of the lumbar vertebrae in 328 females, subject erect.

Centimeters	Males %	Females %
3.0–3.9	0.0	2.0
4.0–4.9	7.5	23.1
5.0–5.9	32.0	46.3
6.0–6.9	38.0	24.2
7.0–7.9	18.1	2.8
8.0–8.9	4.8	0.8
9.0–9.9	0.6	0.5
10.0–10.9	0.3	0.0

FIG. 12. Width of spleen shadow and per cent of its occurrence in centimeter zones in 331 males and 338 females, subject erect.

end of the spleen is upper zone four, 7.6 to 10.0 cm. above the interiliac line, where it occurs in 39.2 per cent of the subjects. It is found in upper zone three in 38.0 per cent. It occurs more than 7.5 cm. above the line in 50.0 per cent of the subjects and less than 5.1 cm. above the line in 9.8 per cent. This shows a marked sex difference. It is below the line in only one subject, a female.

In Figures 10 and 11, which show the

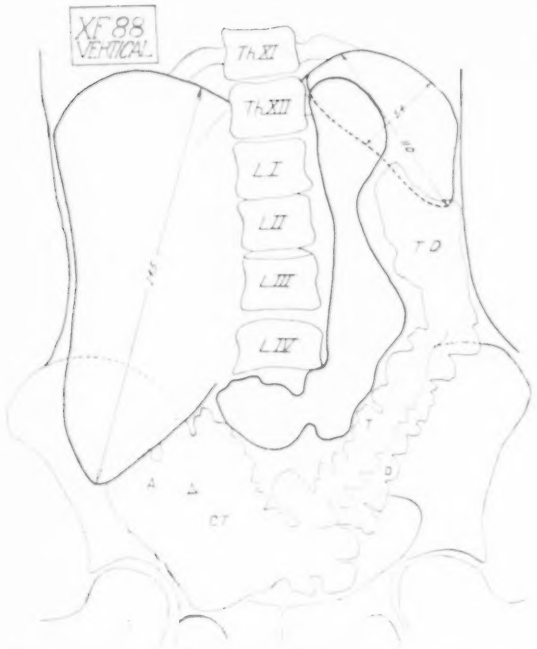

Fig. 13. Liver long, spleen short. In this and similar figures, C denotes cecum; A, ascending colon; T, transverse colon; D, descending colon; CT, cecum and transverse colon; AT, ascending and transverse colon, and TD transverse and descending colon.

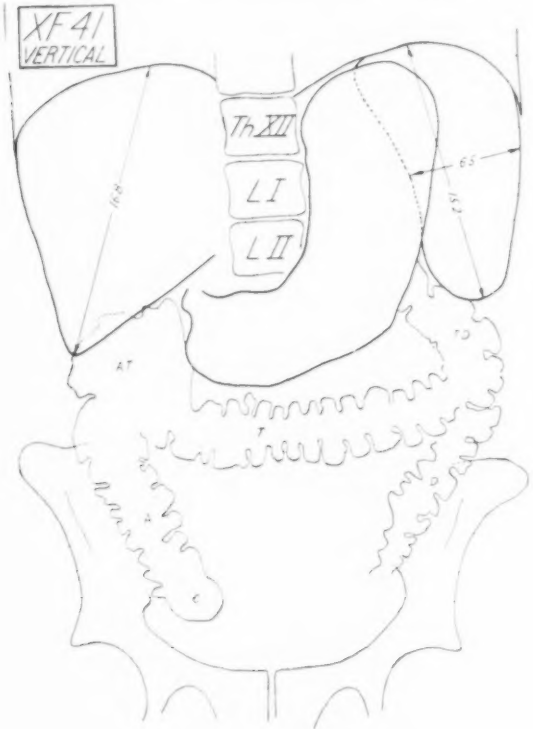

Fig. 14. Liver short, spleen long.

Fig. 15. Liver common length, spleen long.

Fig. 16. Liver long, spleen a common length.

FIG. 17. Long liver in a long abdominal cavity extending 1.3 cm. below the interiliac line.

FIG. 18. Short liver in a short abdominal cavity extending 4.7 cm. below the interiliac line.

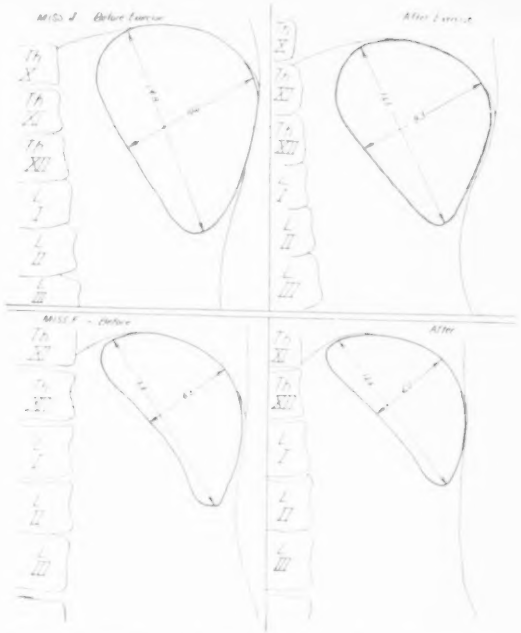

FIG. 19. Decrease in size of spleen due to exercise.

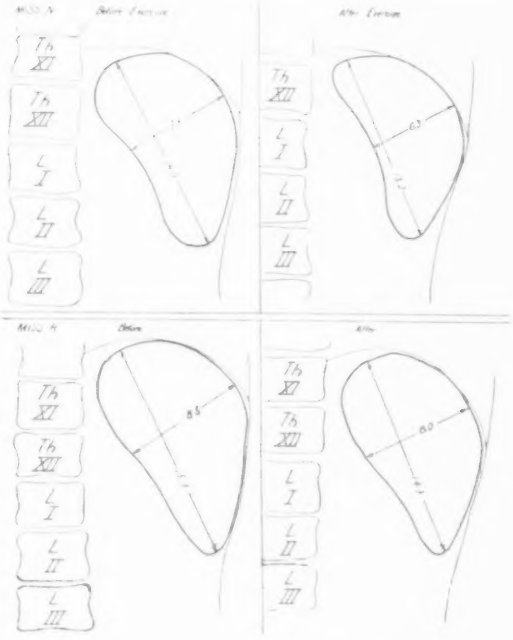

FIG. 20. Decrease in size of spleen due to exercise.

relation of the caudal end of the spleen to the vertebral column, L indicates lumbar vertebra, the plus sign indicates the upper half of the vertebra, and the minus sign indicates the lower half of the vertebra.

The lower end of the spleen varies in its relation to the vertebral column. Its range is from opposite the upper half of the first lumbar vertebra to opposite the

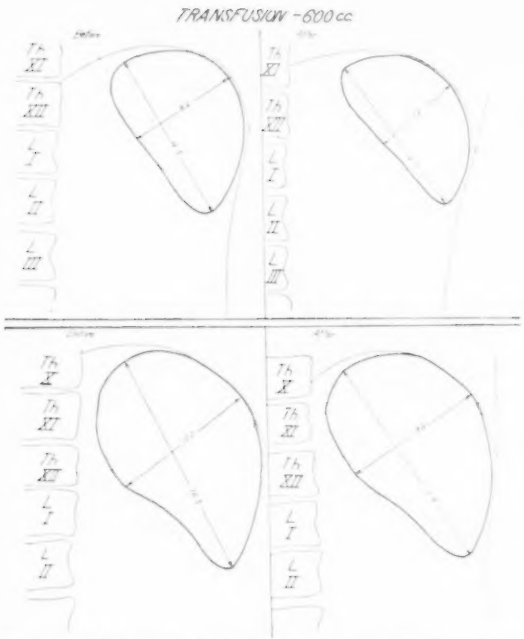

Fig. 21. Spleens of donors before and after blood transfusion.

upper half of the fifth lumbar vertebra. In both sexes, subject erect, its most frequent relation to the vertebrae is opposite the upper half of the third lumbar vertebra. It occurs there in 38.3 per cent of the males, and in 37.8 per cent of the females. It is found lower than this in 25.3 per cent of the males and in 19.7 per cent of the females. This is further evidence that sex is a factor affecting the length of the spleen, and that more males than females have long spleens.

Since in all of the subjects used in this study only 5 or 6 ever had malaria and these had it in infancy, the conclusion is justified that long spleens with their lower ends as low as the upper part of the fifth lumber vertebra are probably normal and their size is probably not due to malaria or to any other disease.

Most textbooks of anatomy give measurements and relations of the spleen based on the study of dead material. They state that the lower end of the spleen is on a level with the spinous process of the first lumbar vertebra. Some of them place it higher. In this series of living subjects, it is most often found two vertebrae lower. In 58.0 per cent of the males and in 54.8 per cent of the females it is opposite the third lumbar vertebra. In only one subject, a female, is it found opposite the spinous process of the first lumbar vertebra. This is a strong indication that what Barcroft and others[4] report in regard to the size of the spleen before and after death in cats and dogs is also true in human beings, namely that the spleen is larger in the living than in the dead.

Neither the width nor the thickness of the spleen could be accurately determined, but the width of the spleen shadow could be measured in most of the roentgenograms. Since such a measurement may be of some value in the interpretation of roentgenograms, the record made of this width is presented. With the subject erect the width of the spleen shadow varies in males from 4.0 to 10.0 cm.; in females from 3.5 to 9.5 cm.

In males the most common width of the spleen shadow is from 6.0 to 6.9 cm., which is its width in 38 per cent of the subjects. In females it is 1 cm. less, from 5.0 to 5.9 cm., which is its width in 46.3 per cent. These measurements correlated with the other measurements of the spleen indicate that more males than females have large spleens.

This study of the spleen establishes for healthy young adults a roentgenographic norm for the length of the spleen, the width of the spleen shadow, and the relation of the lower end of the spleen to the vertebrae and to the interiliac line. It also gives a new picture of the size of the spleen and of its relations.

It is true that there is a general relation between the size of an individual and the size of the liver and spleen but there is not a uniformly definite relation between the size of the liver and the size of the spleen. The liver may be long and the spleen short (Fig. 13), or the spleen long and the liver short (Fig. 14), or the liver the most common length and the spleen long (Fig. 15), or the spleen a common length and the liver long (Fig. 16).

Although the anatomical relations of the liver and spleen depend somewhat upon the size of these organs, yet these relations also depend upon the length of

the abdominal cavity. Figure 17 shows a long abdominal cavity in which a liver 24 cm. long, extends only 1.3 cm. below the interiliac line. Figure 18 shows a short abdominal cavity in which a liver, 21 cm. long extends 4.7 cm. below the interiliac line.

Barcroft and Stephens[3] have shown that exercise decreases the size of the spleen in cats and dogs. In a study begun to determine whether or not this is true in man, roentgenograms were taken of the spleens of some of the students before and after exercise. For exercise the males did a standing run for two minutes, keeping pace with a metronome so that they took 184 steps a minute. The females did the same exercise, some of them running one minute and some of them two.

It is difficult to standardize the amount of exercise taken because different individuals vary so much in the energy put forth in doing a given exercise. It is done much more vigorously by some than by others.

LENGTH AND WIDTH OF SPLEEN SHADOW BEFORE AND AFTER EXERCISE, EXPRESSED IN CENTIMETERS

	Before		After		Decrease	
Females	L.	W	L.	W	L.	W
1	13.5	7.5	13.0	7.0	0.5	0.5
2	14.0	7.3	13.2	6.3	0.8	1.0
3	15.0	8.5	14.3	8.0	0.7	0.5
4	13.8	7.5	13.5	7.5	0.3	0.0
5	13.3	6.3	12.5	6.0	0.8	0.3
6	14.8	10.0	13.5	9.3	1.3	0.7
7	14.0	9.2	14.0	8.2	0.0	1.0
8	12.8	7.4	12.5	6.5	0.3	0.9
9	10.8	5.7	10.5	5.3	0.3	0.4
Males						
1	16.5	9.6	15.4	8.8	0.9	0.8
2	13.0	5.4	12.3	5.3	0.7	0.1
3	15.0	8.2	14.5	8.0	0.5	0.2
4	17.5	9.0	14.5	7.7	3.0	1.3

In 13 subjects of the experiment definite measurements of the spleen could be made. These measurements show that in every one of the subjects there was some decrease in the size of the spleen after exercise, usually in two dimensions. It must be remembered that there may have been a decrease in the third dimension which is not shown in such roentgenograms.

The smallest change in size was in F4 where it was only 0.3 cm. in one of the diameters. The largest change, 3.0 cm. in one diameter and 1.3 cm. in the other was in M4, a member of the University of California track team.

Although the results show some decrease in the size of the spleen after exercise, they do not yet warrant a positive conclusion (Figs. 19 and 20). They do give, however, some evidence that exercise does cause a temporary decrease of the size of the spleen in men as well as in animals.

Some roentgenograms of the spleen were also made before and after blood was taken from two subjects for transfusion. The spleens of the donors were somewhat smaller after the transfusion (Fig. 21).

Thanks are due to Carol H. Kidder for assistance in the preparation of the charts.

CONCLUSIONS

Long livers having their lower tip in the pelvic cavity as much as 5.0 cm. below the interiliac line are normal.

Sex is a factor which affects the length of the liver. More men than women have long livers.

A roentgenographic norm has been established for the size of the spleen in healthy young adults.

The lower border of the spleen is most commonly found opposite the upper half of the third lumbar vertebra.

Long spleens having their lower border on a level with the lower half of the fourth lumbar vertebra are normal. These long spleens are found in individuals who have no history of malaria.

Sex is a factor that affects the length and the shadow width of the spleen. More men than women have long spleens and more men than women have a wide spleen shadow.

There is strong evidence that in human beings the spleen is considerably larger in the living than in the dead.

There is some evidence that exercise decreases the size of the spleen in man and that the loss of blood given for transfusion decreases the size of the spleen in man.

REFERENCES

1. MOODY, R. O., VAN NUYS, R. G., and CHAMBERLAIN, W. E. Position of the stomach, liver and colon; results of roentgenologic study in 600 healthy adults. *J. Am. M. Ass.*, 1923, lxxxi, 1924–1930.
2. PFAHLER, G. E. The measurement of the liver by

means of roentgen rays based upon the study of 502 subjects. Am. J. Roentgenol. & Rad. Therapy, 1926, xvi, 558–564.
3. Gross, L. Studies on the gross and minute anatomy of the spleen in health and disease. *J. Med. Research*, 1910, xxxix, 311–338.
4. Barcroft, J., and others. A contribution to the physiology of the spleen. *J. Physiol.*, 1925, lx, 443–456.
5. Barcroft, J., and Stephens, J. G. Observations upon the size of the spleen. *J. Physiol.*, 1927, lxiv, 1–22.

CHOLECYSTOGRAPHY AND TRANSDUODENAL BILIARY DRAINAGE*

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THE purpose of this paper is, first, to present our findings with cholecystography and those with transduodenal biliary drainage, then to correlate these findings with the clinical and operative data.

The study is based on a series of 800 cases which had cholecystographic examinations, carried out by the oral administration of tetraiodophenolphthalein. All were suspected of having gall-bladder disease; 150 of the cases had, in addition, transduodenal biliary drainage; 135 of the cases were operated upon.

FINDINGS WITH CHOLECYSTOGRAPHY

1. *Normal.* A gall-bladder was considered normal if it was of smooth outline and even density when filled with dye, and if it emptied itself to less than half its size within two hours after a fatty meal. Its position in the abdomen was considered of little significance. As a rule, the situation of the gall-bladder was high and transverse in stout patients; lower, near the spine, and more vertical in thin individuals.

A displacement of the gall-bladder may be apparent rather than real due to the position in which the patient is roentgenographed. Examination of the gall-bladder with the patient standing showed it to descend in some as much as $2\frac{1}{2}$ inches. The liver was seen to descend the same distance as the gall-bladder.

2. *Pathological.*

(*a*) *Failure to Visualize.* Failure of the gall-bladder to visualize with the dye after two examinations was presumed to be due to a pathological condition, most commonly to cystic duct block caused either by stones or by cholangitis; less commonly to block in the common duct or to disturbed function of the gall-bladder. However, it may also occur as a result of metastases or adhesions to adjacent viscera. In cases of jaundice where the van den Bergh reaction (blood bilirubin) showed high figures (1 to 50,000 and a positive direct reaction) there was also failure to visualize the gall-bladder.

(*b*) *Transparencies.* When transparencies were seen within the gall-bladder shadow they were evidence of calculi which are not opaque to the roentgen ray. Many of these cases, in addition, showed faint visualization, insufficient emptying after food, and distortion, the latter being frequently due to adhesions. The greatest difficulty in some cases of this group was to distinguish transparent gallstones from gas in the colon. Points of differentiation are greater transparency of the gas, extension of the gas outlines beyond the shadow of the gall-bladder, and shifting position of the transparencies seen in different roentgenographic examinations. Here, especially, absolute suspension of respiration and immobilization of the body are essential in order to demonstrate the stones.

(*c*) *Calcifications.* This group includes all cases which showed calcified stones, sand, or calcification in the gall-bladder wall. Most of these gall-bladders failed to visualize with dye. In some patients, it could not be determined whether the stones

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in the right upper quadrant were in the kidney or gall-bladder, or extrinsic to both, until the dye was administered. Some of these patients showed both radiopaque and radiotranslucent stones after the administration of the dye.

(*d*) *Faintness of Shadow.* A gall-bladder was considered to be faintly visualized when its shadow was of the same or lesser density than that of the liver or kidney. We have not, however, considered this finding alone as reliable evidence of a pathological condition. As has been brought out by other workers, faintness of shadow depends on too many uncontrollable factors. If, however, in addition to faint visualization, the gall-bladder did not empty properly after the fatty food, we were fairly certain that we were dealing with a pathological condition.

Before the advent of the Graham test, it was claimed by some workers that visualization of the gall-bladder on the roentgenogram meant that it was diseased. We have repeatedly found such cases to be normal. On the other hand, we have cases where the gall-bladder was visualized before administration of the dye as a rather large faint shadow, which remained constant in size, shape and density after the dye and after fatty food. These have been found to be cases of hydrops of the gall-bladder.

(*e*) *Adhesions and Distortion.* The diagnosis of adhesions and distortion should be made only after the exclusion of all other causes that may give an irregular shadow to the gall-bladder. Often apparent distortions are due to projection of the gall-bladder at curious angles. In some cases, the evidence of adhesions has to be confirmed by a gastrointestinal examination.

(*f*) *Incomplete Emptying.* In this group are included only those cases which filled normally but did not empty sufficiently after fatty food; that is, the cases in which the gall-bladder shadows two hours after such food remained larger than half the size they had been before.

FINDINGS WITH TRANSDUODENAL BILIARY DRAINAGE

Transduodenal biliary drainage was attempted in 150 patients. It was successful in 80 per cent of the cases. In 20 per cent the tube did not enter the duodenum. Cholecystography is more readily performed with few unsuccessful attempts.

The drainage test was carried out in the following manner: The duodenal tube is passed on an empty stomach after the patient has rinsed the mouth with a mouth wash. To pass the tube more readily into the duodenum after it has reached the stomach, the patient is made to lie on the right side. Atropinization may or may not help to relax the pylorus. When the tube enters the duodenum, alkaline bile-stained fluid can be obtained. Moreover, if water is injected through the tube, it cannot be recovered. At this point about 25 c.c. of a 30 per cent solution of magnesium sulphate is slowly injected. In a short time, the bile will begin to flow, coming out in drops, if the end of the tube is held below the level of the recumbent patient. This is collected in a series of test tubes.

The first bile obtained is supposed to come from the common duct and is called the "A" bile. It is normally of a clear golden color and its specific gravity is about 1.010. The next bile obtained is supposed to come from the gall-bladder, and is called the "B" bile. It is normally clear, brown or amber-colored, and its specific gravity is about 1.020. The bile then becomes lighter in color, and is supposed to come from the hepatic ducts, and is called "C" bile. This is normally clear, light yellow in color and its specific gravity is about 1.010. Microscopic study of the normal bile may show an occasional white blood cell, epithelial cell, or cholesterin crystal.

Whether all the "A" bile comes from the common duct alone, or whether all the "B" bile comes from the gall-bladder alone, or whether all the "C" bile comes from the hepatic ducts alone, does not affect the value of the test, because it has been repeatedly shown in our cases that the "B" bile was the same kind as the bile in the gall-bladder at operation. Moreover, in some cases we have been able to visualize the gall-bladder with dye, and then, instead of giving fatty food, we have performed the transduodenal biliary drainage test, and found on roentgen examina-

tion that the gall-bladder had been emptied by the magnesium sulphate.

The usual abnormal findings with biliary drainage in our series were as follows:

1. White blood cells, clumped or in large numbers.
2. Many epithelial cells.
3. Much mucus or debris.
4. Sand or gravel.
5. Many microscopic crystals.
6. Thick viscid bile.
7. Bacteria.
8. No gall-bladder bile (no "B" bile, indicating cystic duct block).

OPERATIVE FINDINGS

As has already been mentioned, 135 out of the 800 cases were operated upon. In the cases operated upon cholecystography showed the following:

1. Normal	17
2. Failure to visualize	50
3. Transparencies	22
4. Calcifications	18
5. Faint gall-bladder shadow and no emptying after fatty food	11
6. Distortion or incomplete emptying	17

Having defined our terms we are now in a position to compare the results of cholecystography and transduodenal biliary drainage as checked by operation.

One hundred and five of the cases had both tests performed; in 96 of these we were able to arrive at a coincident diagnosis of either normal or abnormal; 40 cases out of the 105 were operated upon and a discrepancy noted in only 3. This would indicate that in both the operated and non-operated cases, the findings coincided in over 90 per cent of the cases. In 2 of the 3 cases operated upon showing a discrepancy between the two tests, normal drainage responses were obtained, but the dye test manifested adhesions which were verified at operation. The third case showed adhesions by the dye test and no "B" bile by the drainage test. At operation, the gall-bladder was considered normal by the surgeon and was not removed. When it is considered that the two tests are so different from each other in their method, it is noteworthy that such a high percentage of the cases should give like results with both tests.

In order to illustrate how the various roentgen findings check with duodenal drainage, clinical data and operation, there have been listed, in Tables I to VI, 5 typical cases of each cholecystographic group with this information.

In Table I are found 5 typical cases that gave a normal dye test. Drainage was normal in all, the histories were not typical of gall-bladder disease and operation revealed a normal viscus.

In Table II are listed 5 typical cases that failed to visualize with dye. The histories are characteristic of gall-bladder disease. Most of these patients were in the more acute stage of the disease. A smaller number, not included, had chronically diseased gall-bladders that did not function. Biliary drainage showed absence of "B" bile (gall-bladder bile). Operation showed definite gall-bladder disease and, in most cases, stones. One can formulate the rule that no "B" bile usually means no gall-bladder visualization with dye.

In Table III are listed 5 typical cases that showed transparencies in the gall-bladder with dye. Here again the histories are characteristic. Biliary drainage either fails to give "B" bile or gives abnormal findings, such as clumped white blood cells, many cholesterin crystals or much debris. Operation revealed the stones demonstrated with dye.

In Table IV are listed 5 typical cases that showed calcifications in the gall-bladder. These gall-bladders usually failed to visualize with dye. The histories are of long-standing chronic cholecystitis with exacerbations. Usually no "B" bile is obtained and in addition there are other pathological findings in the bile. Operation revealed the stones demonstrated.

In Table V are listed 5 typical cases that showed faintness of the shadow and no emptying after fatty food. Here again the gall-bladder history is typical. Biliary drainage in 3 of these cases yielded no "B" bile. This is a special group which we have made in the classification of cholecystographic cases. In these, before the dye, with the dye and after fatty food, a very large, pyriform, faintly visualized gall-bladder is seen which at no time changes in size or density. We do not feel that in

TABLE I
NORMAL

Clinical Data	Dye Test	Drainage Test	Operation
Pain right upper quadrant and right lower quadrant 18 yrs. Dyspepsia made worse by food	Normal; p.c. empty	Normal	Normal gall-bladder
Pain right lower quadrant, nausea, fever, 2 wks.	Normal; p.c. $\frac{1}{4}$ remaining	Normal	Normal gall-bladder; chronic appendix
Pain right upper quadrant $1\frac{1}{2}$ yrs.; tarry stools 5 mos. ago	Normal; gall-bladder displaced; p.c. $\frac{1}{4}$ remaining	Normal	Normal gall-bladder
Gripping pains epigastrium, 3 wks.	Normal; p.c. empty	Normal	At autopsy normal gall-bladder; coronary artery disease
Epigastric pain, vomiting, weakness	Normal; p.c. empty	Normal	Normal gall-bladder

TABLE II
FAILURE TO VISUALIZE

Clinical Data	Dye Test	Drainage Test	Operation
Right upper quadrant attacks 11 yrs. Last 3 wks. several attacks with nausea and vomiting. Tender right upper quadrant	Failed to visualize with dye, 2 examinations	No "B" bile	Chronic cholecystitis with many small stones
Epigastric pain and dyspepsia 6 mos. Tender right upper quadrant	Failed to visualize with dye	No "B" bile. "A" and "C" bile and epithelial cells	Small stones in neck of gall-bladder and cystic duct
Epigastric pain—attacks 10 yrs, with nausea and vomiting	Failed to visualize with dye	No "B" bile	One large and several small stones. Acute cholecystitis
Right upper quadrant attacks—jaundice past 8 days. Now clearing	Failed to visualize with dye	No "B" bile	Many small stones in gall-bladder and cystic duct
Right upper quadrant severe attacks 2 yrs., with vomiting and jaundice. Fatty food bring on attacks	Failed to visualize with dye	No "B" bile	One large and several small stones in gall-bladder

TABLE III
TRANSPARENCIES

Clinical Data	Dye Test	Drainage Test	Operation
Epigastric attacks radiating to shoulder 5 yrs.	Transparencies; p.c. $\frac{1}{2}$; distortion	"B" bile, many cholesterin crystals	3 large, several small stones
Repeated attacks in epigastrium radiating to back	Many small transparencies; p.c. empty	No "B" bile	Many small stones in gall-bladder and ducts
Right upper quadrant attacks—diabetes worse during attack	Transparencies; p.c. $\frac{1}{4}$ remaining	6.25.25 "B" bile cholesterin crystals. w. B.c. 4.20.26 no "B" bile	Several small stones in gall-bladder
Right upper quadrant attacks 2 yrs. with vomiting	Transparencies; p.c. $\frac{1}{2}$; distortion	No "B" bile	Several small stones in gall-bladder, adhesions to duodenum
Right upper quadrant attacks with nausea and vomiting	Several transparencies	"B" bile—many cholesterin crystals and much debris	Several stones; adhesions to omentum

TABLE IV
CALCIFICATIONS

Clinical Data	Dye Test	Drainage Test	Operation
Attacks right upper quadrant 12 times in 6 mos. with jaundice. Large mass in right upper quadrant	Calcified stones in gall-bladder and ducts. Failed to visualize with dye	No "B" bile, many W.B.C. and epithelial cells in "A" and "B" bile	Chronic cholecystitis with stones in gall-bladder and ducts
Attacks right upper quadrant, 10 yrs.....	Large irregular calcified gall-bladder; p.c. same size	Dark viscid bile, much mucus and debris. Many epithelial cells	Calcified gall-bladder full of stones and debris
Right upper quadrant pain 6 mos.; mild attacks	Many calcified stones. Failed to visualize with dye	No "B" bile. "A" and "C" cholesterin crystals	Calcified stones in gall-bladder
Right upper quadrant attacks with vomiting and jaundice, 2 mos., deepens during attacks	Large calcified stones. Failed to visualize with dye	No "B" bile. "A" and "C" cholesterin crystals	Calcified stones in dilated pouch of common duct
Right upper quadrant attacks 14 yrs. with vomiting	Full of calcified stones. Failed to visualize with dye	No "B" bile	Chronic cholecystitis. Full of stones.

TABLE V
FAINT SHADOWS

Clinical Data	Dye Test	Drainage Test	Operation
Pain upper abdomen radiating to back with chills and fever during attacks, 2 mos.	Faint visualization; p.c. all remaining.	No "B" bile.	Hydrops with stones, cystic duct block, pericholecystic abscess.
Fatigue, clay stools, loss of weight and appetite—8 wks. Jaundice.	Faint visualization; p.c. all remaining.	No "B" bile.	Autopsy—hydrops. Carcinoma of pancreas.
Pain right side abdomen and back. Chills and fever each attack.	Faint visualization; p.c. all remaining.	No "B" bile. "A" and "C" bile, much debris. Few cholesterin crystals.	Hydrops—thickened gall-bladder wall with acute inflammation.
Right upper quadrant frequent attacks with vomiting 5 yrs.	Faint visualization; p.c. all remaining.		Hydrops—stone in Hartmann's pouch. Adhesions.
Right upper quadrant attacks—2½ yrs. with jaundice.	Faint visualization; p.c. all remaining.		Subacute cholecystitis. Hydrops. Stones impacted in ampulla of gall-bladder.

these cases the gall-bladder fills with the dye. Moreover no "B" bile was obtained with drainage. At operation they were found to be hydrops of the gall-bladder with cystic duct block.[1]

In Table VI are listed 5 cases that showed adhesions, distortion or insufficient emptying after food. Though the histories in a number of these patients are typical of gall-bladder disease, this is not always so. As we have already said, adhesions to the gall-bladder are difficult to recognize. Distortions may be apparent but not real. Biliary drainage usually yields "A," "B" and "C" bile, and in most instances it is abnormal. Seventeen patients in this group were operated upon. Most of them had chronic cholecystitis, with adhesions. However, 4 of the gall-bladders which showed distortion were not removed. In the first, the viscus looked normal; in the second, the surgeon cut the adhesions; in the third and fourth, a subtotal gastrectomy was done for duode-

TABLE VI

DISTORTION OR INCOMPLETE EMPTYING

Clinical Data	Dye Test	Drainage Test	Operation
Pain epigastrium, 6 wks.; jaundice, 2 wks., clearing up now.	Poor emptying; p.c. $\frac{2}{3}$ remaining.	No "B" bile. "A" and "C". Many W.B.C. and crystals.	Gall-bladder, slight inflammation. Thick gall-bladder bile.
Epigastric pain radiating to left shoulder 5 yrs. continuous; sour eructations, tender deep epigastrium.	Poor emptying; p.c. $\frac{2}{3}$ remaining.	No "B" bile 2 examinations.	Gall-bladder not removed.
Dull pain epigastrium, belching, feeling of fullness—9 mos.	Adhesions; p.c. $\frac{1}{4}$ remaining.	"B" bile. Many W.B.C.	Adhesions to omentum cut; gall-bladder not removed.
Pain right upper quadrant $3\frac{1}{2}$ yrs. radiating to right shoulder in attacks—Dyspepsia, tender right upper quadrant.	Adhesions; p.c. $\frac{2}{3}$ remaining; poor emptying.	Thick "B" bile. Many cholesterin crystals.	Marked pericholecystic adhesions. Thick gall-bladder bile just as found by drainage.
Upper abdomen attacks radiating to right shoulder 8 yrs. occurring about once a month.	Adhesions; p.c. $\frac{1}{8}$ remaining.	Normal.	Marked pericholecystic adhesions.

nal ulcer which had been diagnosed by roentgen examination with a barium meal and which had caused the distortion of the gall-bladder by adhesions.

It is our opinion that many of these patients are very much like those with chronic appendicitis and that they will prove to be a stumbling block to all of us. We feel that the surgeon should have other very strong indications before operating upon patients who have abnormal "A," "B" or "C" bile and show adhesions or poor emptying of the gall-bladder, until our knowledge about this group is more certainly established.

SUMMARY

1. Over 90 per cent of our cases that had both duodenal drainage and the Graham test gave similar results insofar as they both pointed to a normal or abnormal condition.

2. A gall-bladder that gives a normal Graham test and a normal duodenal drainage test is usually normal at operation.

3. Failure to obtain "B" bile (gall-bladder bile) by the drainage test, usually means failure to visualize the gall-bladder with dye and a pathological gall-bladder at operation.

4. Gall-bladder cases that have stones, either calcified or radiotransparent, usually yield pathological bile by the drainage test and often no "B" bile.

5. Visualization of the gall-bladder without dye is not of diagnostic aid. A large gall-bladder, however, which visualizes faintly before and after dye and does not empty after fatty food means a definite pathological condition; in our cases a hydrops of the gall-bladder. The drainage test yielded no "B" bile in our cases.

6. We feel that the surgeon should have other strong indications before operating upon patients who have abnormal "A," "B," or "C" bile and whose gall-bladder shadows show adhesions or poor emptying.

REFERENCE

1. Snow, William. Diagnosis of hydrops of the gall-bladder by the Graham test. *J. Am. M. Ass.*, 1928, xc, 1536.

THE STUDY OF A CASE OF BRONCHOHEPATIC FISTULA WITH ROENTGENOSCOPIC OBSERVATIONS*

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THE formation of a bronchohepatic fistula is rare enough to warrant considerable interest in the factors involved in its production and the means of establishing the diagnosis. The finding of bile-stained sputum, together with a suggestive clinical history, has sufficed in the past to make the diagnosis previous to operative relief of the condition. The use of lipiodol to show the fistulous tracts has not been reported except in the cases of Oetiker,[3] and Escudero et al.[1] In the case of the patient reported here, it did not seem feasible to use lipiodol as the diagnosis was apparent from roentgenoscopy.

It is a striking phenomenon to see in the roentgenoscope a column of fluid ascending from a dense mass, which appears to include the diaphragm and the dome of the liver, up along a branch of the bronchus to the trachea and then a part of it shooting up into the mouth on coughing, with the expectoration on the instant of bile-stained, purulent material. Examination of the films of the chest, in the case reported here, was somewhat disappointing (Figs. 2, 3, and 4) because there was little to be seen aside from a high right diaphragm, a mass at the base of the right lung, and thickening of the structures in the hilus region, especially in the direction of the mass at the base. No definite fistulous tract or column of fluid could be visualized. It was only during roentgenoscopy, while the patient was coughing or compressing the abdominal muscles, that the tract was filled with fluid and was visible.

This case is an excellent illustration also of the remarkable power of repair on the part of the lung in the presence of extensive injury by all sorts of irritating substances which the epithelium of the trachea, bronchi, and alveoli possesses, and of which we are so frequently unaware. Bile, necrotic liver tissue and pus, besides countless organisms were constantly irritating these so-called delicate structures for months with little visible permanent disability.

A review of the cases of bronchohepatic fistulae reported in the literature, together with a detailed outline of the clinical and operative data of this case, are being reported by Morton and Phillips from this clinic so that only a brief résumé of the important features of the case are included here. Special emphasis is laid upon the details of interest to roentgenologists, and what we consider to be the main factors in establishing the diagnosis of bronchohepatic fistula from the data accessible to the roentgenologist.

CASE REPORT

The patient, A. R., aged fifty, a doctor's wife, came in with a complaint of cough with expectoration of yellow sputum. The history dates back four or five years, at which time the patient had a rather typical attack of gallstone colic. Attacks occurred every three or four months, with severe pain in the right side just below the rib margin both front and back, associated with vomiting but without jaundice. One year before entry, a cholecystectomy was done, and a diseased gall-bladder with many stones was found. A week following the operation, the patient developed a fever and pain in the region of the wound. Films taken at this time (Fig. 1) showed a rather immobile, high, right diaphragm; and a definite diagnosis of subdiaphragmatic abscess was made. Exploratory operation was immediately performed, but no abnormality could be detected. The patient continued to have fever and pain in the right side.

After a particularly severe period of coughing and fever, the patient began to expectorate bile-colored sputum. This continued for three months, during which period she remained in the hospital,—with many weeks in bed at home afterward. The fever and cough gradually decreased so that about eight months after the operation she was feeling entirely well. Four months before entering this hospital, attacks of pain and vomiting recurred for a few days, much resembling the previous gall-bladder attacks, following which she felt

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entirely well. She was apparently entirely normal up to six weeks before admission when she had a severe attack, one evening, of vomiting of bile. This lasted all the next day. Ever since that time the patient has had a recurrence of the cough and expectoration of bile-stained sputum with a slight amount of fever. She was rather prostrated and weak and was confined to bed. Coughing occurred in paroxysms resembling whooping cough and lasted several hours, with the production of a thin, mucoid, bright yellow sputum, though occasionally it was green or white and very frothy. There was no hemoptysis at any time. The amount of sputum was rather constant throughout the day and night and was not expectorated in great amounts at any one time. The patient stated that this left a very bitter taste. There was a marked loss of weight though her appetite was good.

Fig. 1. Film made one week following cholecystectomy, and one year before film shown in Figure 2. The right diaphragm has ascended to the level of the 5th rib.

Fig. 2. The diaphragm is seen one rib level below the abscess mass at the right base (shown by the arrow). The fistula is not visible (see Fig. 3), though the dense shadows around the right inferior main bronchus indicate its position.

Physical examination on admission showed a well-developed and well-nourished middle-aged woman who looked tired and pale but seemed to be in no discomfort. Temperature 37° C., pulse 84, respiration 22, blood pressure 104 66. There was a rather constant, violent, racking cough with expectoration of large amounts of bile-stained, mucoid sputum without odor. The examination was essentially negative except for the following findings. There was some tenderness to pressure over the right rib margin. Examination of the chest showed some slight dullness to percussion over the right base posteriorly with a few râles front and back, especially at the right base; and in the right infraclavicular region down to the base and out to the posterior axillary line, there was increased vocal and tactile fremitus. There was a wide linear abdominal scar in the right upper quadrant with a near-by scar from a drainage wound. The liver and spleen were not palpable, and there were no masses evident. There was no clubbing of the fingers. The red blood count was 3,500,000; hemoglobin, 82 per cent; white blood count, 7,700; differential: polymorphonuclears, 76 per cent; lymphocytes, 20 per cent; mononuclears, 4 per cent. Urine showed very little trace of bile, no albumin or sugar, and otherwise was negative. Blood Wassermann, negative.

Sputum 75 to 100 c.c. daily; bright yellow in color, odorless, mucoid; no tubercle bacilli present; mixed bacterial flora; positive for bile. There was bile in the stool. There was bilirubin present in a dilution of one to two in the serum. Phenolsulphonephthalein test was normal. Blood chloride, 469 mg. per 100 c.c.

Roentgenoscopic examination of the chest on two successive days (Figs. 2 and 3) (May 3 and 4, 1926) showed the same findings. The excursion of the left diaphragm was increased. Its outline was clearly defined. The costophrenic angle was clear and sharp. The left lung was more brilliant than usual, and the markings stood out sharply, especially in the apex. The rib spaces on this side were wider than on the opposite side. The hilus region on the left was considerably increased in density; and extending towards the apex, there was a

marked amount of peribronchial thickening. At the left base there was considerable mottling around the bronchi, suggesting localized areas of bronchopneumonia. The heart had been pulled to the right and was fixed in position. The right chest was markedly abnormal. The peribronchial thickening, noticed in the left hilus, was very marked on the right; and the

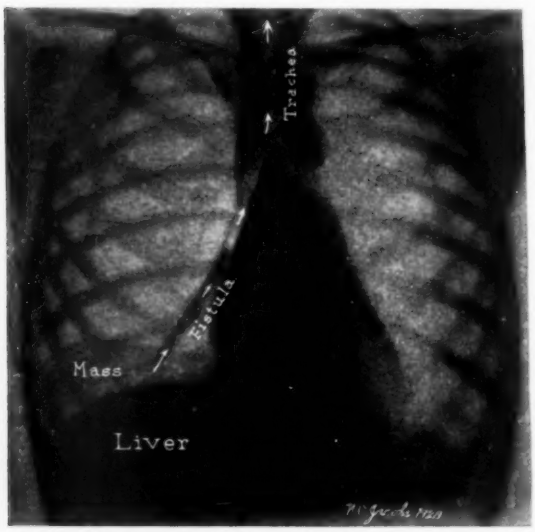


Fig. 3. Diagram made from sketches from the roentgenoscopic notes combined with the changes seen in the films (see Figs. 2 and 4–6) showing the column of fluid in the fistulous tract extending from the mass at the right base toward the hilus region.

course of the bronchi could be traced well out towards the apex and the periphery. There was a considerable degree of mottling at the base on this side. Thickened masses extended downward along the inferior right main bronchus and obscured the right border of the heart. The diaphragm on this side did not move with respiration, and the outlines were obscured by a shadow of uniform density, more dense than the liver. The liver outline was very low, the upper border being almost at the level of the 11th rib. The upper border of a shadow in the region of the right diaphragm came to the level of the 9th rib in the posterior axillary line. There was considerable haziness and mottling at the right base in the lung parenchyma above this mass at what normally would be the region of the dome of the right diaphragm. There was a tract about 2–3 cm. wide extending from the hilus along the course of the right lower main bronchus down into this dark mass (Figs. 2 and 3). With the roentgenoscope, when the patient coughed, a fluid column about 2 cm. in diameter could be seen to shoot with great rapidity upward from the region of the dome of the right diaphragm along this dense tract into the trachea, and the patient then spat up bile-stained sputum. The column was seen to be projected to the level of the bifurcation of the trachea and seemed uniform in diameter the whole length. The column of fluid in the fistulous tract would move up and down on change

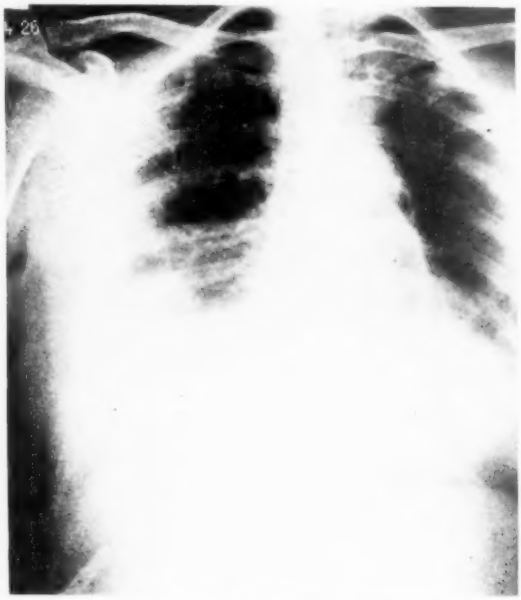


Fig. 4. Film made after the second operation showing the drainage tube in the region of the diaphragm near the drainage tract from the dome of the liver and base of the lung.

of the patient's position. In the lateral view, the posterior mediastinum was obliterated except in the supracardiac area just below the clavicles. The mass in the region of the right diaphragm seemed to be slightly posterior to the middle, but its greatest diameter occupied the region normally below the dome of the diaphragm, midway between the front and the back, and about 6 cm. medially from the mid-axillary line. Because of the difficulty in differentiating this from the liver, this was not to be considered an accurate localization of a subdiaphragmatic abscess. There was apparently well-expanded lung around the upper part of the abscess-tract, especially laterally and posteriorly. The findings suggested a bronchial fistula to a large abscess at the base of the right lung in the region of the right diaphragm, which extended into the liver. The extent of the lesion was not well shown in the films but was quite clearly seen roentgenoscopically.

Chest examination four days later showed

that the diffused mottling previously present in both lung fields had cleared up. The peribronchial thickening extending into the apices from the hilus was still present. The area previously described at the right base had changed in character somewhat and had lessened in density slightly. The diaphragm was apparently at the level of the 10th interspace and above this was a group of hemispherical shadows with dense upper margins, suggesting that several small abscesses in this region had emptied out leaving cavities. The medial border of this area connected with the dense area thought to be the fistulous tract. Below the empty cavities which measured 2 to 4 cm., there was still a very dense shadow above the level of the diaphragm. This was about 3 cm. in width and extended from the 10th rib to the 11th interspace. The liver could not be sharply differentiated from it but appeared to run into and below this region, if not actually occupying all of it. The findings suggested that the bronchopneumonic process had cleared up and that an abscess cavity above the diaphragm and, perhaps, in the base of the lung with possible expansion into the liver had partially emptied itself.

On May 10, 1926, following resection of the 9th and 10th ribs, the diaphragm was split on the right down to the region of the fistulous tract and drains left in place.

On May 10, 1926, stereoscopic films of the chest, taken with the portable unit, showed a resection of the 11th rib for a space of about 8 cm. A rubber tube was in place through the operative site and extended into the dense area below the base of the right lung and well up to the level of the 10th vertebra. It was definitely below what appeared to be the diaphragm on this side and was lateral to and 1 cm. beneath the large cavity previously described in this region. The upper border of the cavity was at the angle of the scapula in these films. The lung fields above this area and also on the left were quite brilliant and contained an unusual amount of air. There were no areas suggesting bronchopneumonia. The fistulous tract could not be readily identified though there was a large dense area running up lateral to the spine towards the hilus of the lung. The liver was still rather low with its lower border 2 cm. below the right costal margin.

On May 12, 1926, a partial pneumothorax developed on the right.

On May 14, 1926, under gas anesthesia, a large abscess cavity over the dome of the diaphragm was entered. A large amount of foul-smelling, slightly bile-stained pus was removed. The patient was in very bad condition at this time but stood the operation fairly well. A transfusion of 500 c.c. of citrated blood was given. Following the removal of this pus, the patient had a rather stormy period in which bronchopneumonic processes were

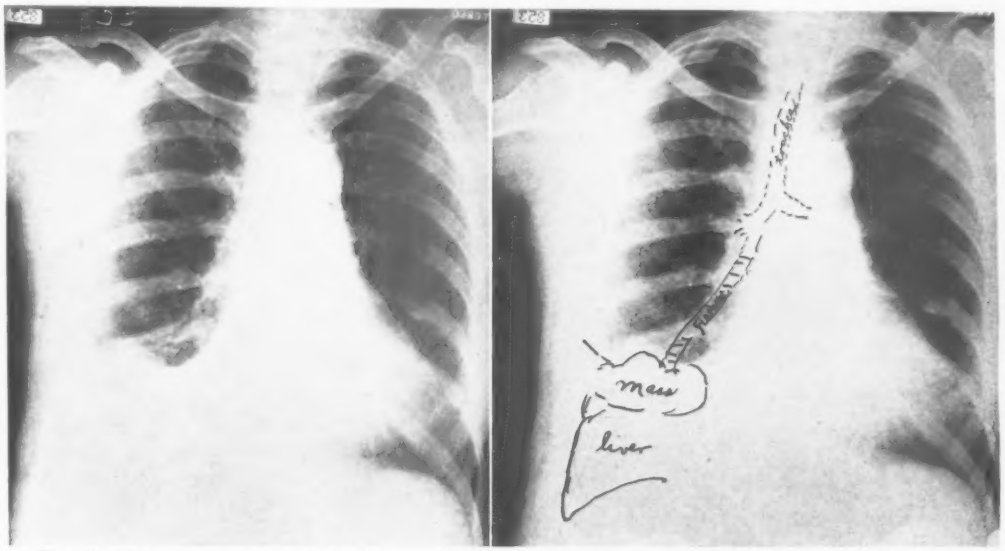


Fig. 5. Showing the mass at the right base and the dense hilus and bronchial shadows at the right base. The fistula no longer connects with the liver abscess but still drains the abscess at the right base in the mass on the diaphragm.

Fig. 5a. Diagrammatic representation of condition present in Figure 5.

present in various portions of the right and left lung fields at different periods, probably as a result of aspiration of some of the purulent sputum. The pneumothorax gradually subsided. There was some hydrothorax (bilateral). Gradually, however, her condition improved. The amount of sputum decreased in quantity and had less bile content.

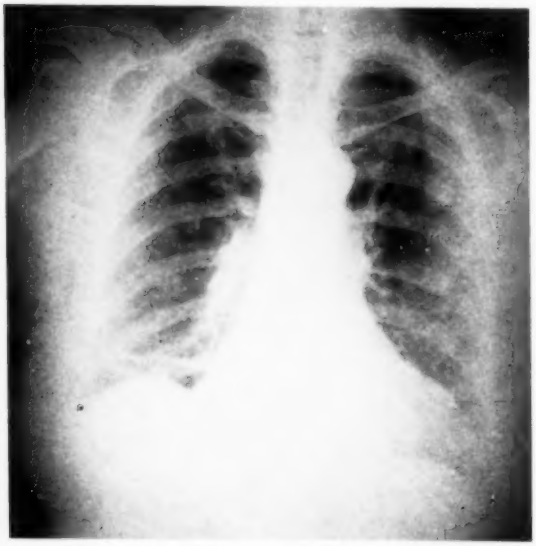


Fig. 6. Film taken fifteen months after discharge from the hospital, showing the small amounts of fibrosis at the right base and the relatively high right diaphragm.

On May 22 and 24, 1926, films of the chest (Fig. 4) showed the drainage tube in place on the right with its tip between the 10th and 11th ribs in the anterior axillary line. There was a collapse of the right lung with pneumothorax, bilateral hydrothorax, displacement of the heart and trachea to the left. There were small patches of bronchopneumonia in the left lung.

On June 19, 1926 (Figs. 5 and 5*a*), the fluid in the left chest had disappeared. The right diaphragm was high, rather flat, and the angles were almost entirely obliterated by fluid and adhesions, the general aspect of the diaphragm being concave upward instead of convex. There was a band of dense, fibrotic material extending from the hilus through the region of the right, main, inferior bronchus toward what was previously the dome of the diaphragm where the base of the lung was rough and irregular. This corresponded roughly to the previous tract of the fistula from the liver to the trachea through this region. The upper surface of the liver came well up under the 10th rib; but between it and the upper surface of the diaphragm, there was still a dense, irregular mass, which on the film, measured approximately 2.5 cm. in thickness. The right lung field was now quite bright and showed the bronchial markings quite plainly. There was considerable peribronchial thickening extending up into both apices. The hilus lymph nodes were somewhat enlarged, especially on the right. The heart was still somewhat pulled to the left. In the right anterior axillary line, there was still a defect in the body wall in the region of the 10th interspace, about 3 cm. in width and extending inward 4 cm. From the inner aspect of this depression in the body wall, there was a dark, rather sinuous shadow leading to the dome of the right diaphragm in the neighborhood of the adhesion previously described. This may have been an artefact but suggested the course of the fistulous or drainage tract from the subdiaphragmatic region to the outside.

As the discharge through the wound had subsided, and the cough had disappeared, the patient was discharged on June 14—very thin, weak and pale, but without jaundice.

July 9, 1926. Aside from weakness, the patient felt well,—coughed occasionally, had no sputum, and was gaining weight.

October 15, 1926. The patient had regained 20 pounds in weight,—no cough and no complaints.

The discharge diagnosis was "subdiaphragmatic abscess, bronchobiliary fistula, bronchopneumonia, pneumothorax."

September 27, 1927. One year later the patient re-entered the hospital for a fracture of the 8th rib on the left side, following an automobile accident. Roentgenoscopy of the chest showed no limitation of the motion of the diaphragms, with the right rather high and showing some tenting over the dome. Lying horizontally across the base of the right lung field, there was a band of dense connective tissue just above the right diaphragm. There was some increase in the hilus shadows in both sides, especially on the right extending down into the right base, but this was not unusually prominent (Fig. 6). There was some haziness at the left base suggesting a slight thickening of the pleura. There was a moderate amount of peribronchial fibrosis throughout both lung fields. The heart musculature was flabby. The rib resection had almost completely healed. From the appearance, roentgenoscopically or on examination of the films, there was no reason to suspect the previous fistula. There has been no cough or jaundice, and the patient has been entirely well since discharge a year ago.

The cardinal signs, from the roentgenological viewpoint, of a bronchohepatic fistula depend upon the presence of a fixed, high, right diaphragm; an abscess mass in the neighborhood of the diaphragm, either above or below, with direct connection to the liver and bile ducts, and a column of fluid in a dilated bronchus leading from this mass to the trachea, together with the expectoration of bile-stained sputum. In a badly jaundiced patient with a lung abscess not connected with the liver, bile-stained sputum may confuse the issue, but the motion of the right diaphragm will not be restricted. In the case of an empyema at the right base with bronchial fistula in a jaundiced patient, the difficulty in differentiation would be great, but in this case the diaphragm, though fixed, would be fixed in a relatively low position. With a large liver pushing the diaphragm up before it became fixed, the differentiation would be impossible by roentgenological methods and must depend entirely upon the history and clinical findings.

Careful roentgenoscopic study of this type of case is of the greatest importance in view of localization for operative relief of the condition, even though the patient be very weak. Films in this particular case have yielded little information as to the site of the fistula because of the absence of a fluid column. Lipiodol instillation might have aided considerably in studying the extent of the abscess cavities, but the patient was too ill to permit of much manipulation before and for some time after the operation so that it was felt unadvisable to do more than simple roentgenoscopy which gave ample information, together with the films, to justify operative interference through the diaphragm.

We wish to emphasize again the cardinal roentgenological signs of a bronchohepatic fistula:

1. A high, fixed, right diaphragm.
2. An abscess mass near the diaphragm and involving the liver.
3. A column of fluid extending from this to the trachea.
4. The expectoration of bile-stained sputum.

REFERENCES

1. Escudero, P., Terrada, M. H., and Miranda Gallino, M. Radiologic exploration of fistula between liver and bronchi. *Rev. Soc. de Med. Int.*, 1925, i, 563–566.
2. Morton, J. J., and Phillips, E. W. Bronchobiliary fistula; review of recorded cases other than those due to echinococcus and amebic abscess. *Arch. Surg.*, March, 1928, xvi, 697–754.
3. Oettiker, L. Expectoration of bile. *Schweiz. med. Wchnschr.*, 1926, lvi, 501–502.

A CASE OF FOREIGN BODY IMPACTED AT THE DUODENOJEJUNAL FLEXURE

BY J. EDWIN HABBE, M.D.

MILWAUKEE, WISCONSIN

THE roentgen-ray observation of the passage of foreign bodies of all kinds along the gastrointestinal tract is a not uncommon occurrence in the practice of the busy roentgenologist, especially if some of his work is being done in the hospital. We have learned by experience that, with very few exceptions, these foreign bodies which are ingested by mouth, whether they be safety-pins, needles, coins, toys, or what-not, will, if they succeed in passing through the esophagus and stomach, almost certainly continue their course uneventfully and be expelled spontaneously, the patient remaining none the worse for the experience.

It was the writer's privilege a short time ago to observe the passage of a sharp double-edged Gillette safety razor blade which was swallowed along with two large iron bolts by an inmate of an insane asylum. The only precaution observed by the patient in swallowing the blade was to wrap it loosely in a small strip of handkerchief in order to prevent its cutting the tongue or buccal mucous membrane. On successive days, by roentgen-ray examination the blade was seen in the stomach, terminal ileum, transverse colon, and rectum, at which last point a proctologist intervened and removed the blade through a proctoscope. To the surprise of all observing the case, no symptoms were complained of by the lunatic at any time during the passage of the foreign bodies or thereafter.

While no case of exactly similar nature to the one herein reported can be found on perusing the recent literature, it is well known that foreign bodies which lodge for a prolonged period of time in either the esophagus, stomach, or bowel, sooner or later give rise to local pathological conditions. Jenkinson[1] reported a case of foreign body (two false teeth on a small plate) which had been lodged in the middle third of the esophagus for a period of sixteen days, at which time the patient was admitted to the hospital with a clinical diagnosis of stricture of the esophagus. (The patient was unaware of the presence of the foreign body because it had been swallowed during sleep.) The plate had already become adherent to the esophageal mucosa during the comparatively short period of its lodgment, but after its successful removal with the aid of an esophagoscope the symptoms disappeared quickly and completely.

In the stomach the persistence of a foreign body may give rise to symptoms of gastric irritation, or if of the hair-ball variety may even simulate malignant new-growth. Tescola[2] reported a case of a young woman, aged twenty, who presented a gastric ulcer history in which the roentgenograms revealed the presence of a part of a needle in the stomach, the foreign body having been swallowed eight months previously.

Rose and Carless[3] state that foreign bodies made up of fecal material with or without gallstones as nuclei, may by their increase in size during passage downward through the small intestine, the lumen of which decreases in size from the duodenum to the ileum, become impacted in the lower ileum and give rise to acute intestinal obstruction. Knox[4] also mentions the ileocecal valve as the common site for an enterolith or other foreign body to give rise to intestinal obstruction.

Carman,[5] in his discussion of foreign bodies in the intestinal tract, speaks especially of those which through gradual enlargement in the sigmoid or rectum cause marked dilatation of the colon proximal thereto.

The following case is reported because of the rarity, so far as the writer has been able to determine by referring to the recent literature, of foreign bodies becoming impacted at the duodenojejunal flexure:

CASE REPORT

R. S., a colored child, aged five, swallowed a nail and within a few hours thereafter became

FIG. 1. Left lateral view of abdomen showing nail outside of and posterior to stomach.

FIG. 2. Right lateral view of abdomen showing nail in terminal duodenum.

frightened and told her mother. The mother carefully observed the child's stools for a period of about ten days; at the end of this time, having failed to recover the nail, although the child was without complaint, she decided to consult a dispensary physician. The child was at once referred for roentgen-ray examination. By preliminary roentgenoscopy the nail was easily visualized in the upper abdomen lying across the midline at the level of the second lumbar vertebra, its estimated length being slightly less than 2 inches. The first thought, naturally, was that the nail had failed to pass out of the stomach. However, a barium meal disclosed the fact that the nail was definitely outside the stomach and careful roentgenoscopy with the patient in the oblique and lateral positions proved it to be still in the alimentary tract and lying semi-perpendicularly in the terminal (ascending) portion of the duodenum.

The appropriate soft pultaceous diet was advised by the attending clinician, and the child was repeatedly observed in the roentgen department at forty-eight hour intervals for a further period of ten days, at the end of which time, although no symptoms of intestinal irritation had developed, an operation was advised as a prophylactic measure by the consulting surgeon. The abdomen was opened through a high midline incision, the nail located by palpation in the terminal duodenum, and

FIG. 3. Gastrointestinal study three months after operation reveals normal functioning of duodenum.

the foreign body "milked" around the duodenojejunal flexure and into the upper jejunum where a small opening was made in the gut

and the nail removed. The gut was sewed up and the abdomen closed without drainage. The patient made a speedy and uneventful recovery, and was discharged from the hospital two weeks after the operation. A check-up barium examination of the alimentary canal made three months after operation revealed normal appearance and function of the stomach, duodenum, and lower intestinal tract.

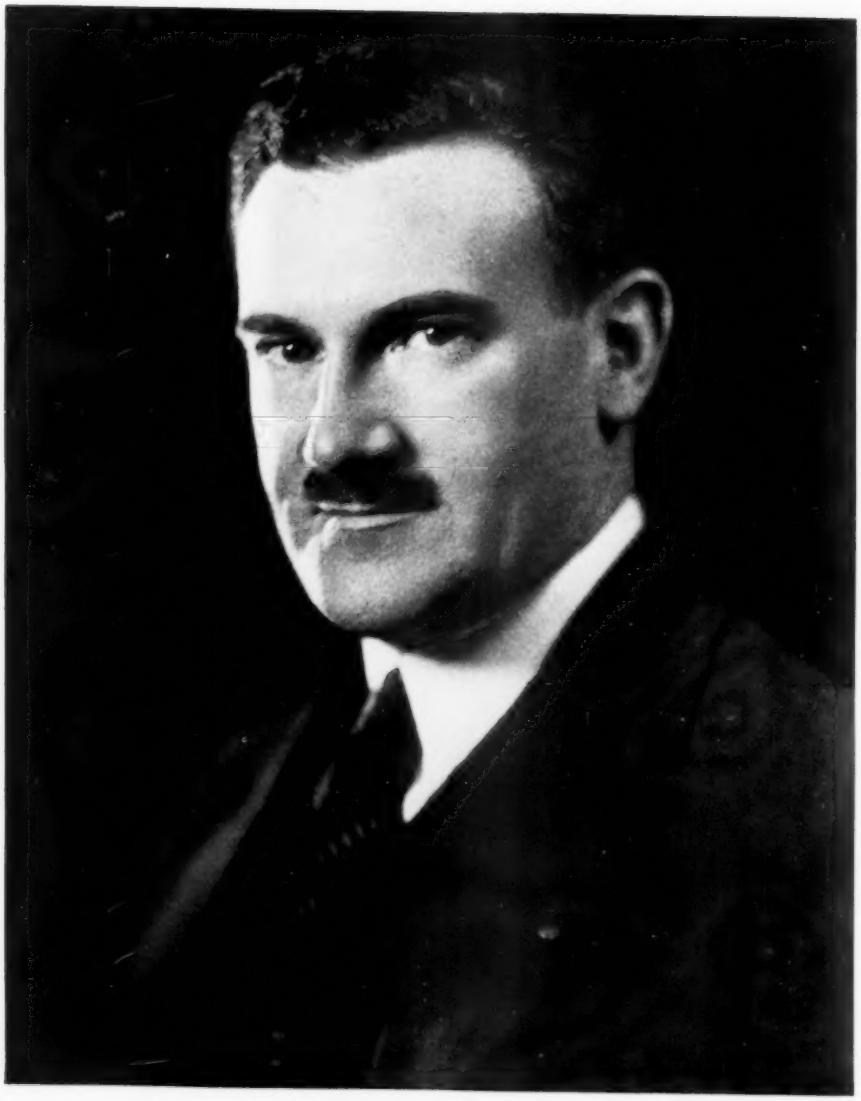
Operative interference in this case was deemed entirely justifiable because of the failure of expectant and medical therapy over a period of three weeks and because of the ease of the operation.

SUMMARY

A case of foreign body (nail $1\frac{3}{4}$ in. long) impacted in the terminal duodenum for a period of approximately three weeks, is reported. The patient remained symptom-free throughout the entire period of its lodgment. After failure of expectant and medical therapy over a three-week period, operative removal was performed. A check-up roentgen study of the gastrointestinal tract made three months after operation revealed no evidence of abnormality; hence it is reasonable to assume that this patient will be no more prone to organic gastrointestinal disease in later life than if she had never swallowed the foreign body.

REFERENCES

1. JENKINSON, E. L. Obstructing foreign body in the esophagus unknown to patient. *J. Radiol.*, 1923, iv, 248–250.
2. TESCOLA, CARLO. Sindrome di lesione ulcerativa gastrica da corpo estraneo (ago). *Radiol. med.*, 1926, xiii, 5–10.
3. ROSE and CARLESS. Manual of Surgery. Tenth edition. Wm. Wood & Co., N. Y., 1920.
4. KNOX, ROBERT. Radiology and Radio-Therapeutics. Second edition. The Macmillan Co., N. Y., 1927.
5. CARMAN, RUSSELL D. Roentgen Diagnosis of Diseases of the Alimentary Canal. Second edition. W. B. Saunders Co., Philadelphia, 1921.



E. H. SKINNER

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Information of interest to all readers will be found on page ii.

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Fourteenth Annual Meeting: Portland, Oregon, July 8–9, 1929.

Committee on Arrangements: To be announced.

EDITORIALS

HISTORICAL DEVELOPMENT IN THE DIAGNOSIS OF PEPTIC ULCER

BY JACOB BUCKSTEIN, M.D.

NEW YORK CITY

IN 1904, nine years after the epochal introduction of the roentgen ray, Rieder[1] published a paper in which he advocated the ingestion of large doses of bismuth subnitrate, which he demonstrated to be entirely harmless, as a substitute for artificial insufflation of the stomach with gas, a method not altogether devoid of danger. By means of this newer method it was possible to demonstrate roentgenographically, in the most detailed manner, the contour as well as the size, shape and position of the different parts of the gastroenteric canal. Moreover, he stated that the motor functions could similarly be studied. According to the experimental work of Pawlow on dogs, the motor movements are the same for milk and water as for bismuth. He prophesied that the extensive use of the roentgen procedure in the digestive tract would be of great value in the field of medical practice, and would in the future contribute materially to the support of the diagnosis in gastric and intestinal diseases.

Two years later Hemmeter[2] published the results of his researches. He produced ulcers in rabbits and cats experimentally by cutting out a ring of tissue, one centimeter in diameter from the stomach and removing it down to the circular layer of muscle. He then coated this denuded surface with bismuth subnitrate, and after closing the abdomen, he was able to visualize this region by means of the roentgen ray.

He then endeavored to demonstrate in a similar manner the presence of such experimentally produced denudations by introducing a bismuth suspension into the stomach of the animal, through a tube, so as to cause the bismuth to spread over the lesion. This could be done provided less than forty-eight hours had elapsed, as the base of the ulcerated area was rapidly covered with granulation tissue.

In a like manner he endeavored to visualize the gastric ulcer of the human being, by having the patient drink a suspension of bismuth in water on an empty stomach. Owing to the fact that the chronic ulcer forms a crater, frequently covered by an agglutinating transudate, he believed that this would mechanically cause the bismuth to adhere, and be demonstrable with the roentgen ray. He succeeded in doing so in three cases. One of the patients in whom an ulcer was diagnosed in this manner was operated on by Dr. Deaver and the ulcer found.

Although theoretically plausible and historically a brilliant contribution, the method of Hemmeter did not prove of great practical value.

It remained for Reiche[1] to put the diagnosis of chronic gastric ulcer upon a firm and sound foundation. He had occasion to examine a patient, aged forty-seven, with a history of serious gastric disturbance of several years' duration, by means of the roentgen ray. He noticed in the picture a stomach filled with bismuth, and in the middle of the lesser curvature, a mushroom-shaped protuberance. After seven and one-half hours, the stomach was still almost entirely filled, but emptied at twenty hours. At this time the projecting area was also free of bismuth. The patient vomited coffee ground material, and passed tarry stools. At autopsy, an ulcer of the lesser curvature was found, round, about

[1] Rieder, H. Radiologische Untersuchungen des Magens und Darmes beim lebenden Menschen. *München. med. Wchnschr.*, 1904, li, 1548–1551.

[2] Hemmeter, J. C. Neue Methoden zur Diagnose des Magengeschwürs. *Arch. f. Verdauungskr.*, 1906, xii, 357–363.

[1] Reiche, F. Zur Diagnose des Ulcus ventriculi im Rontgenbild. *Fortschr. a. d. Geb. d. Rontgenstrahlen*, 1909, xiv, 171–173.

the size of a quarter, deeply penetrating and with smooth margins. The floor of the ulcer was formed by the pancreas, and within it was a vascular lumen closed by a fresh thrombus. The depth of the ulcer in the extirpated organ was not as great as one might have been led to believe from the size of the pouch in the roentgen picture.

In this remarkable paper Reiche proved the following points of a fundamental character:

First, a practical method of diagnosis of chronic gastric ulcer by means of the pouch-like projection of the lesser curvature of the stomach seen in the roentgenogram. This was verified with absolute certainty by autopsy.

Second, that the method of Hemmeter was not very practical, since none of the bismuth adhered to the ulcer when the stomach became empty.

Third, that although the ulcer was not present at the pylorus, and no constriction was noted in that region, a serious disturbance in gastric motility resulted, giving rise to retention to a pathologic degree.

Fourth, that actual size of the ulcer did not correspond to the apparent size as seen in the roentgenogram. This Reiche explained by assuming that the increased intragastric pressure pushed out the non-resistant ulcer bearing area, devoid of its muscular layers and thereby excluded from peristaltic activity.

Haudek[1] in 1910 elaborated upon and popularized the roentgen method in the diagnosis of ulcer. He verified its practical value in several cases that were proven to be correct by surgery or autopsy.

He summarized the roentgenologic evidence as follows: (1) A diverticular-like projection of the stomach, generally of the lesser curvature; (2) a gas bubble above it; (3) a residue of bismuth in it for a protracted period; (4) the inability to influence this area by palpation. Of all these, however, the first, namely, the presence of a niche, is the only absolute diagnostic criterion.

In a later publication Haudek[2] refers to the interesting fact that with ulcers of the pars media a twenty-four hour gastric retention may be present, although at operation the pylorus has been found to be intact. Reiche had similarly shown profound disturbance of motility in the case he reported.

Both Haudek, and later Eisler, refer to the significance of the spastic contractions of the musculature which may occur with mucosal ulceration. This may lead to the development of a functional hour-glass stomach, which may exist for years without producing cicatricial contraction (Schmieden). Schnitzler, Budinger, Moynihan, Schmieden and others were able to observe such spasms on the exposed stomach which persisted for several seconds and minutes.

The gastric ulcer shows a decided predilection for the lesser curvature and particularly for that anatomical pathway of the stomach known as the "Engpass" or "Magenstrasse."[1] Rarely, however, an ulcer may occur on the greater curvature. Finsterer and Glaessner[2] reported such a case, which was confirmed at operation, showing that the ulcer of the greater curvature had penetrated into the lower pole of the spleen, with adhesions to the pancreas.

The development of the conception of the niche as a criterion in the diagnosis of the gastric ulcer may be similarly noted in the problem of duodenal ulcer.

Rieder[3] states that a crater-shaped or perforating duodenal ulcer may give roentgen findings similar to those of a callous or penetrating ulcer of the stomach, namely, a niche-like area within the duodenum, and localized tenderness on pressure over this region. Schwarz and Holzknecht showed that either cicatricial or spastic stenosis of the duodenum could be demonstrated roentgenologically.

Haudek in 1912[4] and in 1913[5] emphasized two main points of diagnosis: (1) The presence of duodenal stenosis, which may be a sequel, giving rise to contraction, or,

[1] Haudek, M. Zur rontgenologischen Diagnose der Ulzerationen in der Pars media des Magens. *Munchen. med. Wchnschr.*, 1910, lvii, 1587–1591.

[2] Haudek, M. Die Technik und Bedeutung der radiologischen Motilitatsprufung. *Verhandl. d. deutsch. Kong. f. innere Med.*, 1912, xxix, 143–148.

[1] Aschoff, L. Lectures on Pathology. P. B. Hoeber, New York, 1924, pp. 279–312.

[2] Finsterer, H., and Glaessner, J. In de Milz penetrierendes Ulcus der grossen Kurvatur des Magens. *Mitt. a. d. Grenzgeb. d. Med. u. Chir.*, 1913, xxvii, 126–140.

[3] Rieder, H. Das Röntgen-Verfahren im Dienste der Pathologie und Therapie des Magen-Darm-Kanals. *Verhandl. d. deutsch. Kong. f. innere Med.*, 1912, xxix, 17–41.

[4] Haudek, M. Der radiologische Nachweis des Ulcus duodeni. *Med. Klin.*, 1912, viii, 181–184; 224–229.

[5] Haudek, M. Die Röntgenbefunde bei Ulcus duodeni und ihre Verwendbarkeit für den Chirurgen. *Verhandl. d. deutsch. Gesellsch. f. Chir.*, 1913, xlii, I. Teil, 73–76.

as an associated concomitant phenomenon due to the presence of the ulcer, namely, spasm. (2) The presence of the niche, consisting of a bismuth deposit within the crater of the ulcer. This is the most valuable sign because it is the only specific one. Unfortunately, it is not so readily demonstrable as the niche of the gastric ulcer, and is not usually evident. The other points he refers to are either doubtful or of secondary value. These are localized tenderness, hypermotility, hyperperistalsis, hypertonicity, pyloric fixation, and the persistence of shadows within the duodenum, other than the niche.

Baron and Bársony[1] reported two cases of duodenal ulcer with a spastic hour-glass involving the pars media of the stomach. At operation only a duodenal ulcer was found. The stomach proved to be entirely normal. Kienböck and also Bier reported similar observations, showing that isolated duodenal disease may produce a spastic hour-glass stomach.

The significance of the persistent duodenal defect in a large series of films was elaborated by Cole.[2]

Fortunately, careful roentgenoscopic observation will frequently demonstrate a persistent duodenal deformity, and limit the necessity for serial roentgenography with a large number of films. The safest procedure is the combination of roentgenoscopy and roentgenography, with one acting as a check upon the other.

The significance of the niche in the diagnosis of duodenal ulcer was reëmphasized by Akerlund, particularly in the article which appeared in 1923.[3] He analyzes the evidence under the following points: (1) the niche; (2) constriction, narrowing or defect of the bulb caused by spasm, scar tissue or adhesions; (3) shortening of the bulbar contour, due to spasm, infiltration or adhesions; (4) pouch or diverticulum-like protrusions of the bulbar shadow caused by the formation of a pocket.

Of these, the niche is the most important. He states that the niche of duodenal ulcer is more frequently demonstrable than the gastric niche, and can be visualized in more than 60 per cent of cases.

Chaoul,[1] on the other hand, believes that while the niche is one of the surest signs of ulcer, it is infrequently seen. The cicatricial contractions, spasms and adhesions form small pocket-like projections which may be erroneously interpreted as niche formations.

Carman[2] has frequently demonstrated that in the typical duodenal deformity of ulcer, it is ordinarily impossible to differentiate between the pouch-like irregularity of the niche and the remaining defects of the bulb. Moreover, what actually appears like a niche may be a part of the normal duodenal contour, projecting between two areas which have become involved through cicatrization.

Fortunately, the almost absolute certainty with which the diagnosis of duodenal ulcer may be made, depends not so much upon the demonstration of a niche, as it does upon the presence of a defect that is absolutely persistent, roentgenoscopically as well as on the film, and is unaffected by reëxamination or antispasmodics.

ROBERT KNOX

It is with great regret that we record the news of the death of Dr. Robert Knox of London. Dr. Knox has for many years been known as one of the foremost leaders in roentgen diagnosis and therapy. He was an honorary member of the American Roentgen Ray Society and of the New York Roentgen Society, and at the time of his death was editor of the *British Journal of Radiology*. A detailed account of Dr. Knox's life and his contributions to roentgenology will be published in a later number of the Journal.

[1] Baron, A., and Barsony, T. Spastischer Sanduhrmagen bei duodenalen Affektionen. *Wien. klin. Wchnschr.*, 1912, xxv, 1185–1187.

[2] Cole, L. G. The diagnosis of post-pyloric (duodenal) ulcer by means of serial radiography. *Lancet*, 1914, i, 1239–1244.

[3] Akerlund, A. The roentgen diagnosis of ulcus duodeni with respect to the local "direct" roentgen symptoms. *Acta radiol.*, 1923, ii, 14–30.

[1] Chaoul, H. Zur Diagnose und insbesondere zur Röntgendiagnose des Ulcus duodeni. *Munchen. med. Wchnschr.*, 1923, lxx, 259–261; 302–305.

[2] Carman, R. D., and Sutherland, C. G. The duodenal niche. Am. J. Roentgenol. & Rad. Therapy, 1926, xvi, 101–106.

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this column solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. John T. Murphy, 421 Michigan Ave., Toledo, Ohio.

Thirtieth annual meeting, 1929: To be announced.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. Albert Soiland, 1407 S. Hope St., Los Angeles, Calif.
Annual meeting, Portland, Oregon, 1929.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. Fred M. Hodges, 801 West Grace St., Richmond, Va.
Annual meeting, Portland, Oregon, 1929.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. Robert J. May, St. Luke's Hospital, Cleveland, Ohio.
Fourteenth annual session, Chicago, Ill., Dec. 3–7, 1928.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. W. S. Lawrence, Medical Arts Bldg., Memphis, Tenn.
Next annual meeting, Asheville, N. C., Nov. 12–15, 1928.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St.
Meets second Monday of each month except during the summer months, the place of meeting to be selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. W. T. Bronson, Englewood Hospital.
Meets monthly on second Thursday from October to May (except during month of December) at Virginia Hotel. Dinner at 6 P.M., scientific session at 8 P.M.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. James H. West, 8314 Euclid Ave.
Meetings are held at 6 o'clock at the University Club, on the fourth Monday evening of each month from September to April, inclusive.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. O. J. Shore, 2033 Park Ave.
Meets monthly on second Friday from October to May, at Wayne County Medical Society Building.

CENTRAL ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. H. C. Kariher, Decatur, Illinois.
Regular meetings held quarterly.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. Carl S. Oakman, Muncie, Indiana.
Annual meeting each February 22 in Indianapolis. Next meeting in Indianapolis, February, 1929.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. John D. Camp, Massachusetts General Hospital, Boston, Mass.
Meets monthly on third Friday, Boston Medical Library.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. E. Everett Rowell, 200 West 59th St.
Meets monthly on third Monday, New York Academy of Medicine.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. D. S. Childs, 316 Gurney Bldg., Syracuse, N. Y. Three meetings a year—April, August and November.

PACIFIC COAST ROENTGEN RAY SOCIETY
Secretary, Dr. Harold B. Thompson, Seattle, Wash.
Two meetings a year.

ROENTGEN RAY SOCIETY OF CENTRAL PENNSYLVANIA
Secretary, Dr. W. E. Reiley, Clearfield, Penna.
Two meetings a year, April and October.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. Eugene Pendergrass, University of Pennsylvania, Philadelphia.
Meets monthly on first Thursday evening, Pennsylvania Hospital.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. James M. Flynn, 282 Alexander St.
Meets monthly on the first Friday evening at 7.45 at the Rochester Medical Association Building.

ST. LOUIS ROENTGEN CLUB
Secretary-Treasurer, Dr. L. R. Sante, Metropolitan Building.
Meets first week of each month. Time and place of meetings designated by president.

TEXAS RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. C. P. Harris, Houston, Texas.
Annual meeting, Galveston, Texas, 1928.

VIRGINIA ROENTGEN RAY CLUB
Secretary, Dr. Wright Clarkson, 205 S. Sycamore St., Petersburg, Va.
Annual meeting Oct. 17, 1928.

British Empire

BRITISH INSTITUTE OF RADIOLOGY INCORPORATED WITH THE RÖNTGEN SOCIETY
Director, Dr. John Muir, 32 Welbeck St., London, W. 1.
Meets on the third Thursday of each month, from November to June inclusive, at 8.15 P.M., at 32 Welbeck St., London, W. 1., or as advertised.

ELECTRO-THERAPEUTIC SECTION OF THE ROYAL SOCIETY OF MEDICINE (CONFINED TO MEDICAL MEMBERS)
Meets on the third Friday of each month during the winter at 8. 30 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

RADIOLOGICAL SECTION, AUSTRALASIAN MEDICAL CONGRESS
Secretary, Dr. C. A. Anderson, The Hospital, Dunedin.

* Secretaries of societies not here listed are requested to send the necessary information to the editor.

RADIOLOGICAL SECTION OF THE VICTORIAN BRANCH OF THE BRITISH MEDICAL ASSOCIATION
Secretary, Dr. Colin Macdonald, Lister House, 61 Collins St., Melbourne, Australia.
Meets monthly at Melbourne during the winter.

SECTION ON RADIOLOGY, CANADIAN MEDICAL ASSOCIATION
Secretary, Dr. A. H. Rolph, 160 St. George St., Toronto, Ont.

RADIOLOGICAL SECTION, NEW ZEALAND BRITISH MEDICAL ASSOCIATION
Secretary, Dr. P. C. Fenwick, The Hospital, Christchurch.
Meets annually.

CONTINENTAL EUROPE

BELGIAN SOCIETY OF ROENTGENOLOGY
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

SOCIETE DE RADIOLOGIE MÉDICALE DE FRANCE
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

SOCIETE FRANCAISE D'ELECTROTHÉRAPIE ET DE RADIOLOGIE MÉDICALE
Meets monthly on fourth Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

ASSOCIATION OF GERMAN ROENTGENOLOGISTS AND RADIOLOGISTS IN CZECHO-SLOVAKIA
Secretary, Dr. Walter Altschul, German University, Prague, II/52.

DEUTSCHE RÖNTGEN-GESELLSCHAFT (GESELLSCHAFT FÜR RÖNTGENKUNDE UND STRAHLENFORSCHUNG)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

SUD- UND WESTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

NORD- UND OSTDEUTSCHE RÖNTGENGESELLSCHAFT
Meets annually in different cities.

DUTCH SOCIETY OF ELECTROLOGY AND ROENTGENOLOGY
Holds two meetings a year in Amsterdam, one in the Spring, and one in the Fall.

SOCIETA ITALIANA RADIOLOGIA MEDICA
Secretary, Professor M. Ponzio, University of Turin, Turin.

ALL-RUSSIAN ROENTGEN RAY ASSOCIATION, LENINGRAD, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson.
Meets annually.
Sixth Annual Meeting, 1929, to be announced.

LENINGRAD ROENTGEN RAY SOCIETY
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly on the first Monday at 8 o'clock in the State Institute of Roentgenology and Radiology, Leningrad.

MOSCOW ROENTGEN RAY SOCIETY
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. A. Elektorowicz, 19 Hoza St., Warsaw.
Meets annually.

WARSAW SECTION, POLISH SOCIETY OF RADIOLOGY
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

SCANDINAVIAN ROENTGEN SOCIETIES
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with the exception of the Denmark Society, meets every second month except in the summertime:

SOCIETY OF MEDICAL RADIOLOGY OF SWEDEN
Meets in Stockholm.

SOCIETY OF MEDICAL RADIOLOGY IN NORWAY
Meets in Oslo.

SOCIETY OF MEDICAL RADIOLOGY IN DENMARK
Secretary, Dr. H. Scheuermann, Copenhagen
Meets on the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

SOCIETY OF MEDICAL RADIOLOGY IN FINLAND
Meets in Helsingfors.

VIENNA SOCIETY OF ROENTGENOLOGY
Secretary, Professor Holzknecht, Vienna, IX, General Hospital.
Meets on the first Tuesday of each month from October to July.

NEWLY ELECTED OFFICERS AMERICAN ROENTGEN RAY SOCIETY

At the recent annual meeting of the American Roentgen Ray Society in Kansas City Dr. Edward H. Skinner was instaled as President of the Society and the following officers were elected for the ensuing year: President-elect: Dr. H. M. Imboden; First Vice-President: Dr. D. Y. Keith; Second Vice-President: Dr. W. E. Chamberlain; Secretary: Dr. J. T. Murphy; Member Executive Council: Dr. L. R. Sante.

RADIOLOGICAL SOCIETY OF NORTH AMERICA

The Fourteenth Annual Meeting of the Radiological Society of North America will be held in Chicago, Dec. 3 to 7, inclusive, 1928. The scientific sessions, exhibits, open meetings, and banquet will all be held at

the headquarters, the Drake Hotel. The Society will welcome all radiologists—physicians and physicists—to whom the meeting will prove of interest, whether or not they are members. Those expecting to attend should make hotel reservations without delay, as the prospects indicate a large meeting.

DEVICE FOR KEEPING AND STERILIZING RADIUM NEEDLES

To the Editor:

The need for a device such as the one described here has been felt for a long time. We have until now kept our radium needles, ready threaded, in test tubes for emergency use. The boiling of these needles usually results in the threads becoming entangled and much time and patience is lost in disentangling at the operation. Figure 1 shows a new piece of apparatus. A and B are blocks of copper $^3/_8$ inch thick, and joined together by X and Y which are strips of brass $^3/_8$ inch thick and 15 inches in length. The whole apparatus is silver plated. Block B is drilled on its outer edge, with a number of holes into which the needles fit snugly, leaving only their eyes visible. Block A is drilled on its face with a corresponding number of holes. Each needle is threaded and dropped into a hole in Block B, the thread is then passed over the frame and through the corresponding hole in Block A, and then tied taut. The needles thus secured may be kept safely until required for use. At the time of operation the whole frame is dropped into the sterilizer. Each needle is released individually by a snip across the thread close to Block A. Any needle not required is left in the frame and thus the danger of losing a valuable needle is avoided.

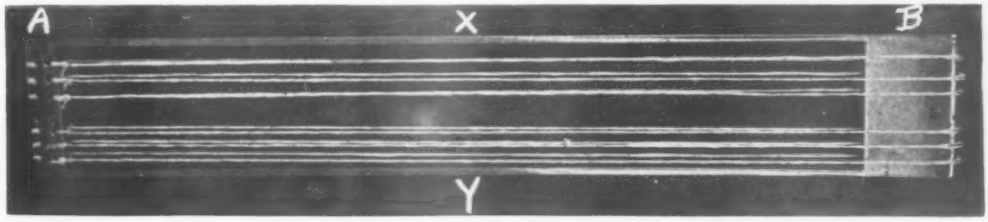

FIG. 1.

CHARLES HINES,
Chief Assistant
Radium Department
Christchurch Hospital.

New Zealand,
July 5, 1928.

Subscribers to THE AMERICAN JOURNAL OF ROENTGENOLOGY & RADIUM THERAPY *visiting New York City are invited to make the office of the publishers (Paul B. Hoeber, Inc., 76 Fifth Avenue, New York) their headquarters. Mail, packages or bundles may be addressed in our care. Hotel reservations will gladly be made for those advising us in advance; kindly notify us in detail as to requirements and prices. List of operations in New York hospitals on file in our office daily.*

DEPARTMENT OF TECHNIQUE

Department Editor: David R. Bowen, M.D., Pennsylvania Hospital, Philadelphia, Pa.

In this department will be published from time to time, as material is available, suggestions for improvement in technique.

A SIMPLE TABLE ATTACHMENT FOR THE GROEDEL TECHNIQUE FOR PULMONARY TUBERCULOSIS, AND FOR LATERAL UPRIGHT CHEST EXAMINATIONS

BY GEORGE E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

GROEDEL[1] has described a method of teleroentgenography for the anatomical diagnosis from the roentgenogram of the degree of pulmonary tuberculosis. In this technique, the tube is 2 meters from the chest wall, as is usual in teleroentgenography, but the film is placed 20 cm. beyond the chest wall. His illustrative cases show that the new method gives a sharper definition to the image of the shadow than does the ordinary teleroentgenographic procedure. It seems to give a more "contrasty" image, and seems to help in the differentiation between the exudative and productive types of tuberculous lesions.

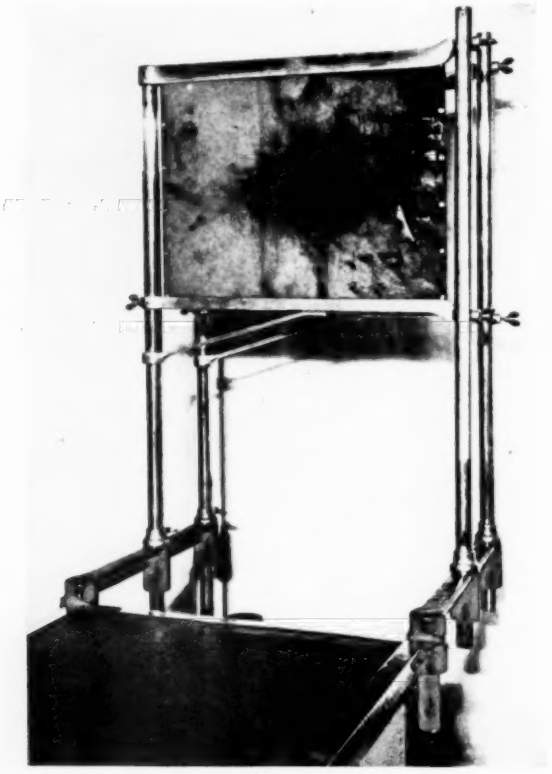

Fig. 1.

No equipment was immediately available for this technique. Therefore, we have had welded to the standard arms at the end of a Kelley-Koett table which hold the upright plate holder, an additional pair of similar arms. The second set of uprights are 20 cm. distant from the first. A bakelite board is placed in the proximal plate or cassette holder against which the patient leans, and the cassette holding the film is in the second holder. The patient is strapped against the bakelite board, and the exposure is made as usual. This simple equipment enables us without much trouble to investigate the claims made by Groedel (Fig. 1).

By omitting this first or proximal plate holder, we have an equipment that will permit lateral views of the chest, which formerly could not be made with comfort in large patients because the upright arms were too near the table. This attachment is arranged for the Kelley-Koett table but can easily be applied to any table.

[1] Groedel, Franz M. Die anatomische Qualitatsdiagnose der Lungentuberkulose aus dem Röntgenbild. *Acta radiol.*, 1926, vi, 469–472.

A SIMPLE SERIALGRAPH DEVICE

BY LOUIS H. LEVY, M.D.

NEW YORK CITY

TAYLOR[1] has just described a device used by him as a film divider, commonly called a serialgraph or polygraph. From his description, this device is to be used in conjunction with a Potter-Bucky diaphragm table. About two years ago another device was described by Kloiber.[2] This, however, can be used only in the upright position.

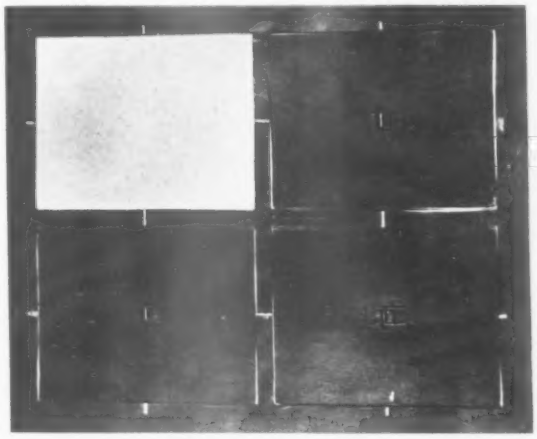

FIG. 1.

For several months, I have been using a very simple device with considerable success. This can be used with the Potter-Bucky diaphragm alone or with the table.

The device consists of a lead panel $13 \times 16 \times {}^{1}/_{32}''$ in which there have been cut four windows $5^{3}/_{8} \times 6^{7}/_{8}''$. Sufficient margin has been allowed around each window to give each picture a distinct border. Each window is fitted with a lead panel to the center of which is fastened a loop for lifting it. In the middle of each border of each window are placed white lines for centering purposes. As soon as the location of the duodenal cap has been determined roentgenoscopically and the patient placed in the proper position on the Potter-Bucky diaphragm, a loaded $11 \times 14''$ cassette with the serial device on top of it is placed horizontally on the cassette holder within the Potter-Bucky diaphragm tunnel. Each window is centered to the center of the cassette holder in succession by shifting the cassette to the proper position. As each window is placed in position for recording purposes, the panel blocking the window is removed, and as soon as the exposure is made the panel is replaced. In this way four exposures, all of the same intensity are made quickly and without trouble. If it is desired to take more than four films more cassettes may be used.

Four windows instead of more were decided upon in order to get as large a view as possible and to include a good part of the prepyloric portion of the stomach, as may be seen by Figure 2.

The writer is indebted to the Victor X-Ray Corporation for its co-operation.

REFERENCES

1. TAYLOR, H. K. Potter-Bucky table adapted for multiple exposures. *Radiology*, 1928, x, 506–509.
2. KLOIBER, H. Modification of the Heyden sliding frame for duodenal exposures. *Fortschr. a.d. Geb. d. Röntgenstrahlen*, 1926, xxxv, 448–450.

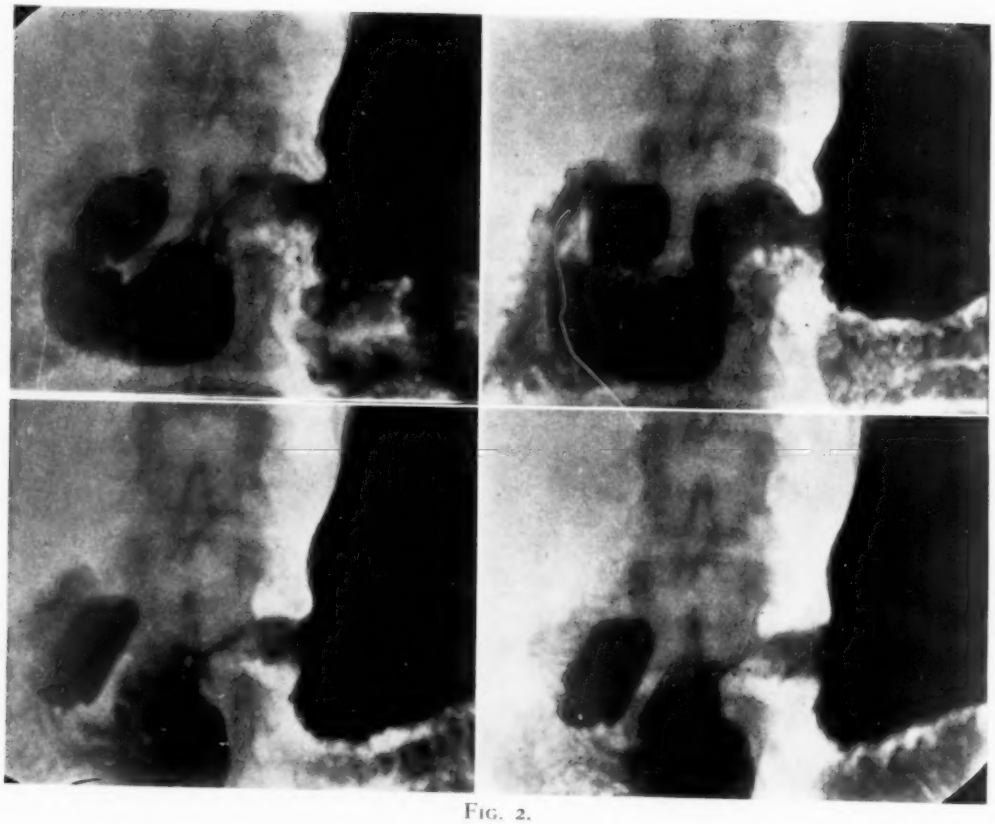

Fig. 2.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

DIATHERMY: ITS PRODUCTION AND USES IN MEDICINE AND SURGERY. By Elkin P. Cumberbatch, M.A., B.M.(Oxon), D.M.R.E. (Camb.), M.R.C., Medical Officer in Charge, Electrical Department, St. Bartholomew's Hospital. Second edition. Cloth. Price, $7.00. Pp. 332, with 87 illustrations. St. Louis: C. V. Mosby Co., 1928.

A TEXT-BOOK OF ACTINOTHERAPY; WITH SPECIAL REFERENCE TO ULTRA-VIOLET RADIATION. By D. D. Rosewarne, M.R.C.S. (Eng.), L.R.C.P. (Lond.), Late Honorary Actino-therapeutist and Assistant Physician, City of London and East London Dispensary. Cloth. Price, $4.00. Pp. 237, with 20 illustrations, including a colored plate. St. Louis: C. V. Mosby Co., 1928.

It seems that our English colleagues have stolen a march on us in the art of physical therapy. There are many reasons for this, of which the most important are, first, the fact that physical therapy was recognized as a valuable adjunct in the treatment of certain diseases by the leading English medical societies as early as 1909 when St. Bartholomew's hospital had established a physical therapy department. Second, during the war, physical therapy became one of the basic forms of therapy, and thus served to give this mode of healing a tremendous impetus. England having entered the war three years prior to the United States, she had that additional advantage of earlier familiarity and experience on a large scale in this new form of therapy.

I have recently read with great interest two books by English authors, published in 1928. One on Diathermy by Elkin P. Cumberbatch; the other on Actinotherapy by D. D. Rosewarne.

The former is a complete treatise on the subject, simply and beautifully written. It is well arranged, and the chapter on the physical basis of diathermy is concise, thorough and lucid. The author perhaps devotes too many pages to descriptions of machines and applicators, since he must know that every intelligent physiotherapist devises his own applicators to suit his own particular needs. The chapters, however, on the actual application of diathermy in different diseases are instructively and thoroughly covered. The book should be on every physiotherapist's desk and on the shelf of every practititioner who is interested in the subject.

The latter book on actinotherapy is the best book I have read on the subject. The author takes it for granted, and justly so, that the physical principles underlying actinotherapy are only superficially, if at all, given in the medical curriculum. He therefore devotes an entire chapter to the physical principles underlying actinotherapy, which though exhaustive is concise and most comprehensive.

In the chapters on treatment the author takes it for granted that the reader is more at home, and he therefore does not go into such minute details as he does in the chapter aforementioned. After a careful perusal of this book, a physician should be equipped to employ actinotherapy whenever indicated. It might be used to great advantage as a textbook on the subject for fourth year medical students.

ISIDORE LATTMAN.

RADIUM IN GYNECOLOGY. By John G. Clark, M.D. Former Professor of Gynecology, University of Pennsylvania, Gynecologist in Chief to the University Hospital, and Charles C. Norris, M.D., Professor of Obstetrics and Gynecology, University of Pennsylvania, Gynecologist to the Radiologic Staff of the Philadelphia General Hospital; with a chapter on Physics by Gioacchino Failla, E.E., M.A., D.SC., Physicist, Memorial Hospital, New York. Cloth. Price, $8.00. Pp. 315, with 49 illustrations. Philadelphia: J. B. Lippincott Co., 1927.

Seldom does the reviewer have such a pleasant task as is afforded by Clark and Norris' Radium in Gynecology. This volume of more than three hundred pages begins its interest in the preface.

The first chapter details the discovery of radium and the events leading up to this; viz, the discovery of radioactivity by Becquerel and the work of the Curies.

Chapter two, Physics of Radium, written by the well-known physicist of the Memorial Hospital, New York, Gioacchino Faillo, is extremely interesting and remarkably well done. He covers the development of the commercial production of radium and methods of standardization of radium salts. That portion dealing with the constitution of matter, and the phenomenon of radioactivity is written in such a clear and concise way that the physician interested in radiotherapy can readily understand it. Under "Practical Considerations," "Dosage," "Quality of Radiation and Fil-

tration," "Absorption," and "Scattering of Radiation by Tissues," and "Distance" are thoroughly detailed.

The third chapter is a consideration of the Pathology and Action of Radium. The effect of radium on the various tissues and organs of the body, especially the uterus and ovary are considered. In the discussion of malignant neoplasms, a plea is made for the proper coöperation of the surgeon, the pathologist and the physicist as necessary for the attainment of successful radiotherapy. Biopsy is strongly favored in the class of new-growths generally encountered by the gynecologist. Their preferred method is a sharp knife followed immediately by the cautery at a dull heat. Although admitting that there are theoretic dangers to the operation of diagnostic curettage, the authors, after carefully weighing the evidence, come out in favor of it.

Chapters four to ten inclusive, give a detailed discussion of the treatment of pelvic neoplasms and diseases with radium, including statistics of results of such treatment. Of especial interest are the discussions of the treatment of cervicitis, dysmenorrhea, sterility, and amenorrhea due to hypofunction of the ovary.

Accuracy in diagnosis is essential to the successful application of radium therapy, and the warning is stressed that radium should be used only by those capable of making an accurate pelvic diagnosis. It is further pointed out that those who attempt to employ radium therapy with insufficient knowledge and experience are likely to do much harm, as are those who treat malignant neoplasms without having a sufficient quantity of radium available.

This book is written with commendable clearness and will be a great help to the gynecologist who wishes to familiarize himself with the indications and technique of radiation treatment. E. W. Titus.

INTERNATIONAL ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ARENS, ROBERT A., and BLOOM, ARTHUR R. A case of chronic appendicitis and calcified fibroid uterus. *Radiology*, March, 1928, x, 256–257.

The authors report the case of a woman, aged sixty-seven, who had suffered with pain in the epigastrium after eating, and who, on roentgenoscopic and roentgenographic examination after barium, was shown to have a calcified fibroid tumor of the uterus and a pathological gall-bladder, in combination with an adherent chronically inflamed appendix. The patient did not come to operation, but the roentgen diagnosis was positively indicative of the above conditions.

ASPRAY, JOSEPH. Results of the oral method in cholecystography. *Radiology*, August, 1928, xi, 99–100.

A total of 498 cases is reported in which the oral method was used, in 312 of which pathology was found. Of this number 80 were operated on, in 79 of which the roentgenologic findings were confirmed. The method used is as follows: the evening before the roentgenograms are made, a dose of bicarbonate of soda is given preceding the first dose of kerasol, then two kerasol capsules every fifteen or thirty minutes until six or eight have been taken, the drinking of plenty of water being encouraged up to midnight. Nothing is eaten until after the 14- and 16-hour films have been made and then a meal rich in fats, such as bacon and eggs with milk and buttered toast is given, after which the third set of roentgenograms is made about three hours later. Of the 498 cases, the effects on the gastrointestinal tract were noted in 408, and of these 366 did not vomit, 36 did vomit and 6 had severe vomiting. It was found that in all cases in which there were evidences of considerable dye in the hepatic flexure region of the colon, cholecystography proved satisfactory. The results by this method have been so satisfactory that the intravenous method is rarely used.

BARROW, S. C. Roentgen analysis of bone disease. *Radiology*, June, 1928, x, 500–505.

In order to more logically study and observe roentgenograms of bones and as an important aid in diagnoses of bone diseases, the author makes use of a chart on which the various observations are noted. By means of these, the roentgenogram, which is also attached to the chart as a permanent record, can be studied more intelligently and the details noted at the time in such a way that they can be interpreted after the entire report is completed. The American College of Surgeons classification with subheads of nomenclature are given in the chart. Pictures of representative charts are given to illustrate the method of diagnosing certain conditions, in this case giant cell tumor, chondroma, osteosarcoma, osteoma and syphilitic osteoperiostitis.

BELOT, J., NAHAN, L., and KIMPEL, J. Involvement of bones in the course of malignant granulomatosis. *J. de radiol. et d'électrol.*, June, 1928, xii, 257–268.

The bones are rarely involved in malignant granulomatosis. Among 33 patients treated in recent years, the authors have found involvement of the bones in only 4. They have not made systematic roentgen examinations and it is possible that such examinations would increase the number of cases. Dresser of Boston, among 95 cases of Hodgkin's disease, found only 4 in which the bones were affected. All of these are old cases in which the patients have had multiple adenopathy for a long time. The vertebrae are most frequently affected, next the sternum and third the spongy parts of the pelvic bones. There are no characteristic clinical symptoms. The roentgen picture shows massive decalcification followed very rapidly by destruction which changes the general appearance of the bone completely. The outline is not very distinct and lacunae appear which give the bone an alveolar appearance. Cancer causes more complete destruction of bone and in active tuberculous foci the demarcation is less distinct and the decalcification more diffuse. But tuberculous osteitis that is recovering and gummatous syphilis give pictures very similar to this and it is impossible to make a roentgen differentiation from certain forms of fibrous osteitis and certain giant cell tumors.

These bone localizations of malignant granulomatosis are very sensitive to roentgen rays and under roentgen treatment the bone regains almost a normal appearance. In the authors' cases they have used a tension of 200,000 volts with an intensity of 3.5 ma., with a filter of 0.5 to 1 mm. zinc or copper and 2 mm. aluminum, with a distance of 40 cm. The treatments are given by the cross-fire method. The dose

per sector is 3500 R, and the series may be repeated after about a month. In cases of disease of the vertebrae this treatment should be associated with immobilization by a plaster cast to avoid compression of the roots and cord.

Brown, Samuel, and Weiss, H. B. The value of lateral views of the thorax. *J. Am. M. Ass.*, Jan. 21, 1928, xc, 187–188.

The lateral view of the thorax is seldom used among roentgenologists, perhaps because of the assumption that stereoscopy of the usual anteroposterior views of the thorax is sufficient to enable one to recognize any existing change in the lungs, pleurae or mediastina. However, the usual stereoscopic views of the thorax do not always reveal every change, and when revealed the exact location and nature cannot always be determined with great accuracy. During the past two years, several hundred chests were examined in the anteroposterior and lateral positions and the information obtained has fully justified the added expense and labor. Illustrations are presented of 5 cases to show the value of the routine use of the lateral view. Where abnormal shadows were recognized in the anteroposterior views, the exact location and probable nature of the shadows were more accurately determined after a lateral examination. Lesions of the lungs behind or in front of the heart, which often escape detection, are readily revealed in the lateral views.

The use of the lateral view in pulmonary tuberculosis is not recommended. The authors find that the superposition of the lungs very often obscures the finer changes in an early tuberculous involvement. In advanced cases of pulmonary tuberculosis, the lateral view may be of much assistance in showing the full extent of the involvement and the exact location of the cavities.

Campbell, D. Barium for three weeks in the intestine? *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, xxxv, 1264.

A brief report and illustration is given of a roentgenogram taken on a seventy-one year old emaciated man, with the object of obtaining pictures of senile bones. Three weeks previously a gastric examination was made on the suspicion of a gastric carcinoma, following which an exploratory laparotomy disclosed an inoperable carcinoma of the stomach. For two days following the patient had no stools, but subsequently there were daily evacuations. Twice it was necessary to employ enemas. The last roentgenogram showed distinct contrasting of the bowels and palpation through the abdominal wall gave evidence of the presence of fecal masses in the intestines. The patient died shortly thereafter, and autopsy disclosed extensive carcinomatosis. The fecal masses in the lower intestinal regions were of viscous pasty consistency. The question arises whether the shadow in the intestines was due to the opaque meal administered three weeks previously or to old thickened feces.

Case, James T. Some pseudo-vesicular shadows and other pitfalls in gall-bladder roentgenology. *Radiology*, July, 1928, xi, 1–6.

In the past before the introduction of the Graham test, it was not uncommon to make a diagnosis of gall-bladder pathology on the basis of a small, rounded ovoid shadow in the right upper quadrant which in all probability was caused by something besides the gall-bladder. With the Graham method, the gall-badder shadow does not coincide with the ovoid shadow formerly supposed to represent the gall-bladder. This ovoid shadow is usually due to a "piling up" of the shadow of the first portion of the duodenum, or to one of the smaller lobes of the liver, or to the pyloric end of the stomach. A diagram is presented showing the positions of the duodenal bulb and the manner in which the ovoid shadow is shown in the region of the gall bladder. Roentgenograms also illustrate these pseudo-vesicular shadows. The very fact that the gall-bladder could be noted in such roentgenograms was formerly taken as an indication of pathology. The visualization of the gall-bladder can be accomplished with certainty only by the ingestion or injection of dye by the Graham-Cole method and any other shadows in the gall-bladder region must be due to something else.

Chaumet, G. Roentgen method for studying the ascending aorta. *J. de radiol. et d'électrol.*, April, 1928, xii, 161–171.

The shadow of the descending aorta is lost in that of the spinal column and it is not visible when it is normal. The same is true of the arch of the aorta; it can be seen traversing the clearness of the mediastinum only when its wall is rendered opaque by a pathological process.

But in the right anterior oblique position as the angle formed by the screen and the plane passing through the scapulas of the subject is increased, the shadow of the ascending aorta moves farther to the right. The vena cava, which in the frontal position is partially covered by the aorta, first becomes tangent to it and then tends to encroach on it. The clear ribbon which represents the left tracheobronchial tract becomes almost rectilinear and moves

toward the right but less rapidly than the aorta so that, though its lower part at first cuts into the opacity of the vessel, it finally becomes tangent to it also. The degree of obliquity at which the aorta and the air passage are tangent, the aorta on the right and the air passage on the left, is practically the same as that at which the aorta and the vena cava are tangent, the aorta on the right and the vena cava on the left. This coincidence gives the maximum visibility of the aorta. Passing from right to left the aorta appears first and then the superimposed air passage and the superior vena cava. The aorta is more opaque than the vena cava and the latter is rendered still more transparent by the superposition of the air passage. This optimum visibility lies between 35° and 45° depending on the subject. Of course it is not a mathematically exact point, the double tangency is not always brought about at exactly the same degree of inclination and there is a little indistinctness, but the best visibility is obtained in this way.

CONTE, E. Partial agenesia of the bones of the skull. *Radiol. med.*, July, 1928, xv, 736–747.

The patient was an unmarried woman of twenty-six, admitted to the hospital for intense headache, visual and auditory hallucinations and defective vision. These symptoms were found to be hysterical in nature. Her mother had been an alcoholic and the three older children in the family had nervous or epileptic disturbances. The top of her head was bald, and roentgen examination showed three irregularly round defects in the bone extending from the bregma to within a few centimeters of the squamous portion of the occipital bone. The father said that when she was born there was a wine-colored spot at the vertex of the skull and the bones beneath it were lacking for a much greater area than that of the normal fontanelles. This region later suppurated. So the defect in the bones of the skull was evidently congenital. The etiology of this condition is very obscure. The author thinks perhaps there had been a hydrocephalus with the formation of a meningocele during pregnancy which was over with before birth. The mother's alcoholism was probably the cause of the nervous taint in the children and also possibly of the bone anomaly.

DOURMASHKIN, RALPH L. A new procedure in the diagnosis of ureteral calculi. *Surg., Gynec. & Obst.*, July, 1928, xlvii, 105–110.

Extraneous shadows lying side by side with the ureter may frequently exhibit typical signs of a ureteral calculus so as to confuse the most experienced. An error is especially possible when the symptoms point to a lesion in the urinary tract on the side on which the shadow is noted. The using of an opaque catheter is one of the most effective methods for dealing with this problem. A possible error may occur even when the opaque catheter is used if the cystoscopist should fail to recognize a double ureter on the affected side. That this condition is not so very rare is indicated by the fact that the author found two such anomalies in a series of 255 cases of stone in the ureter. Another error may be due to a stone floating in the dilated portion of the ureter, in which case its shadow may be seen to be separated from the course of the opaque catheter. The use of the opaque catheter is of no diagnostic value when the shadow in question is found in close proximity to the catheter, as a similar picture may be produced by an extraneous shadow accidentally in juxtaposition with the ureter. In the author's experience the use of the waxed tip catheter has been unreliable.

Recently the author has resorted to a new procedure which depends upon the property of the rubber-bag catheter when introduced into the ureter and inflated to expand not only laterally but in a longitudinal direction as well. The type of rubber bag used is that which is attached to the catheter only at the proximal end. The bag, when introduced to a point even several centimeters below the calculus, will continue to expand until the stone is reached. If the stone is movable it will be pushed up by the inflated bag, sometimes for a distance of 4 or 5 cm. In all cases, the resulting roentgenogram will show a stone above the inflated bag, unless the bag was distended when passed deliberately alongside of the stone, in which case definite indentation will be produced on the side of the bag in contact with the calculus. A rubber bag introduced below the shadow in question, previously noted alongside the ordinary opaque catheter will produce when inflated with an opaque solution a shadow which will be superimposed upon and cause the complete disappearance of any shadow of extra-ureteral origin, while that of a true stone will be seen above the shadow of the bag. It appears that this method is free from all sources of error except in those rare cases where the stone is lodged in a ureteral diverticulum.

DUNHAM, H. KENNON. The value of an *x*-ray study in the care of cases suffering from pulmonary tuberculosis. *Radiology*, March, 1928, x, 217–225.

The present paper points out the value of roentgenograms of the chest in correctly diagnosing the extent of tuberculous lesions

and in determining the method of treatment. That is, by means of roentgen chest examination, it is possible to indicate the amount of rest necessary, the "when, where, how, why and how much a patient should rest." The tuberculous exudate, caseation, scar tissue, etc., can be observed and it may even be possible to indicate whether or not the sputum contains tubercle bacilli. Knowledge of the state of the lesions will be of much aid to the attending physician in the management of his cases. To best read chest plates, the age, race, and symptoms should be known. With a series of plates, the following information should be obtained: whether or not tuberculous lesions, or lesions other than tuberculosis, are present; the type of lesion, adult apical or puerile; are the lesions extending; are the lesions developing in other parts of the lung—new fans or caseous bronchopneumonia; are the lesions becoming more or less dense, or are they breaking down—cavitation; is the tuberculous exudate being absorbed, or has it disappeared; is scar tissue developing, or have old lesions been walled off by scar tissue. With this information available, the roentgenologist is able to advise the attending physician, and become both diagnostician and consultant on tuberculosis.

Eiselsberg, A., and Sgalitzer, M. The surgical importance of *x*-ray examination of the trachea and the bronchi. *Surg., Gynec. & Obst.*, July, 1928, xlvii, 53–68.

In the roentgen examination of the trachea of goiter patients, a lateral view, in addition to the frontal one, is of importance. It is only by means of the double examination in two major axes that one is able to gain definite information as to the changes in the form and position of the trachea. Roentgenoscopy is also of great importance since it enables visualization of a malacia of the cartilaginous rings—an imperative indication for operation because of the danger of death—in addition to affording information as to the presence of possible intrathoracic goiter of changes in the heart or lungs. Malacial changes in the cartilages, together with slight reduction in the resistance of these cartilages, are to be diagnosed by means of the marked dilatation of the trachea upon increase in intratracheal pressure (Valsalva's test) or an abnormal narrowing when the pressure is reduced (Mueller's test). The degree of difference in the size of the lumen depends upon the degree of malacia of the cartilages. To simplify the examination of such conditions of the trachea, it suffices merely to have the patient cough behind the roentgenoscopic screen in order to increase pressure, or to sniff so as to reduce intratracheal pressure. Great difficulties in deciding upon operative or conservative therapy, especially in cases complicated by serious heart lesions, will often be removed by means of such a test on the resistance of the cartilaginous support of the trachea.

A method of introducing a contrast oil into the bronchial tree by means of a catheter for bronchography is reported. The method possesses the advantage over previous methods of permitting constant roentgenologic observation of the treatment from the very beginning. The method also prevents the iodized oil from coming in contact with the buccal mucous membranes. The patient can be brought into any desired position and the direction of the flow of oil in the bronchial tree can be controlled so as to fill any desired part of the lungs at will. Only one side should be filled at a sitting and, if possible, only one lobe.

The most important factor necessary for successful bronchography is complete anesthesia of the bronchus, larynx and the tracheal mucous membrane. Although the method is harmless with good technique, it should be used only with a definite indication in mind, especially for the diagnosis of bronchiectasis.

Eusterman, George B. Limitations of cholecystography with which physicians should be familiar. *J. Am. M. Ass.*, Jan. 21, 1928, xc, 194–197.

Cholecystography is undoubtedly the most valuable single laboratory diagnostic method. Cholecystographic diagnosis requires greater care than most other diagnostic procedures for it has many sources of error both in technique and in interpretation. Previous reports without exception have been misleading in that diagnostic efficiency has been based solely on cases in which operation was performed. Limitations of the method are shown by a large group of cases without any clinical evidence of cholecystic disease in which there was an abnormal cholecystographic response, i.e., false, positive reactions. This is especially true in asthenic or neurasthenic patients with gastric subacidity and lowered basal metabolic rates, in cases of papilloma and in cases of duodenal ulcer. It is essential to repeat the examination after intravenous administration of the dye.

The importance of the high incidence of a negative cholecystographic response in definite cholecystic disease has not been sufficiently stressed. A negative cholecystographic response is the least reliable of all signs. Both the oral and intravenous methods are likely to err in cases in which there are only slight pathologic changes in the gall-bladder. In advanced

disease of the gall-bladder or in cases in which the cystic duct is obstructed, cholecystographic results are strikingly parallel by the two methods.

Further clinical evidence is presented to show that cholecystography is fundamentally a test of gall-bladder function, rather than a method of depicting actual disease of the gall-bladder. The identification of stones as shown by negative shadows is the chief exception. The clinical history and physical examination, including the elimination of the stomach and duodenum as the site of disease by roentgen-ray examination, enables the experienced clinician to make a diagnosis of definite cholecystic disease in more than 90 per cent of the cases. Further physiologic research is necessary to explain the discrepancies that exist in the clinical, pathologic and cholecystographic aspects of cholecystic disease. The adoption of a common standard as to what constitutes adequate gross and microscopic evidence of cholecystic disease is a fundamental necessity to further progress in this field. At the present stage of development, cholecystography should not be relied on to the exclusion of other data to affirm or deny the presence of disease of the gall-bladder.

Evans, James A., and Evans, Edward T. Carcinoma of the splenic flexure of the colon. *Radiology*, May, 1928, x, 438–442.

Carcinoma of the splenic flexure is very rare, ranking next to the descending colon as being the rarest site for carcinoma of the large bowel. The symptomatology is the same as that of other carcinoma of the large bowel between the cecum and the rectum. Because of cecal distention, there is usually pain in the right side. Carcinoma at the splenic flexure is usually of the "napkin ring" type, and it is relatively amenable to surgical treatment because of slow metastasis, the possibility of bloodless resection and easy anastomosis. Preliminary cecostomy should be performed. The authors give a case report of a woman, aged forty-nine, who had been suffering acutely from pain in the lower right quadrant. Roentgenograms after barium meal and enema gave evidence of carcinoma of the splenic flexure of the colon, which was confirmed at operation. Care must be taken, however, to distinguish gas or spasm of the colon in the region of the splenic flexure and descending colon from the filling defect of carcinoma.

Feldman, Maurice. Liver measurement. A comparative study on the relation of chronic gall-bladder disease to the size of the liver. *Radiology*, June, 1928, x, 496–499.

The method employed in this study is the usual gall-bladder technique, the patient lying on the abdomen on the Potter-Bucky diaphragm and a series of films made of the gall-bladder, which includes the liver. The films are made at both inspiration and expiration. The right lobe only is measured, the left lobe being usually obscured by other structures. The vertical measurement is from the upper to the lower border in the nipple line and the oblique measurement from an angle made by the spine, liver and diaphragm to the tip of the right lobe. In this way there is less danger of error and the results are more constant and uniform. In this series of 250 cases of suspected gall-bladder disease, it was found that chronic gall-bladder disease had no noticeable effect on the size of the liver. The average vertical measurement ranged from 11 to 15 cm., and the average oblique measurement from 18 to 21 cm. The size of the liver was apparently not affected by age or sex, and weight has practically no effect on the average size of the liver.

Gottlieb, J. Sources of error in the roentgen diagnosis of kidney stones. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, xxxv, 1256–1258.

Errors of two sorts are to be taken into consideration. In one case the stone (usually uric acid) produces no shadow on the roentgen plate, and in the second a shadow appears on the roentgen plate in the kidney region and is erroneously assumed to be a kidney stone. Assuming good technique, about 2 per cent of cases are usually diagnosed erroneously.

If the clinical symptoms suggest a kidney stone and the roentgenogram is negative, there are two procedures which may bring out the stone. One is to empty the kidney pelvis by means of a ureteral catheter attached to a Record syringe and then to take a second roentgenogram. In a portion of the cases, this procedure permitted the visualization of the "invisible stone." The other method followed during the past two years, consists in filling the kidney pelvis with gas (air or oxygen). In certain cases it was possible to detect a stone at the filling defect observed in pyelography.

To prevent errors from diagnosis of false stones the following procedures are necessary: (1) pyelography; (2) nephroscopy; (3) lateral roentgenography. A report is given of a case of trigonitis, pyelitis and nephroptosis which presented a roentgen shadow in the kidney region. It was found that this shadow was caused by a pigmented nevus on the back of the patient. An unnecessary operation was thus avoided.

Granzow, Joachim. Fatality after childbirth caused by traumatic diaphragmatic hernia. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, xxxv, 1246–1252.

A primipara, aged twenty-eight, entered the clinic at the beginning of parturition. The physical examination of the thoracic organs showed cardiac dullness absent on the left side but present with pulsation to the right of the sternum. The right lung was normal. Above the left lung no respiratory sound could be elicited but tympanitic and loud intestinal sounds could be heard up to the left arm pit. A diagnosis of left-sided diaphragmatic hernia was made. The roentgenogram showed the stomach in the left pleural cavity. The heart and mediastinum were displaced strongly to the right. In order to prevent further forcing of the abdominal viscera into the thoracic cavity during labor, the pregnancy was terminated by forceps delivery. The child was alive, but the mother died half an hour after delivery with all signs of acute suffocation due to mediastinal displacement. An uncontrollable fit of vomiting had tended to force the abdominal viscera upward, thus causing the fatal complication. At autopsy the left pleural cavity was found to contain the enormously dilated stomach, the spleen, a great part of the mesentery, the splenic flexure of the colon with adjoining portions of the ascending and descending colon. The left lung was completely atelectatic and the heart was found displaced entirely to the left side of the body. The diaphragmatic hernia in this case was caused several years previously by a street car accident to the patient.

Grudzinski, Z. Vertebral lymphogranuloma. *J. de radiol. et d'électrol.*, June, 1928, xii, 269–274.

A case of lymphogranuloma is described in a man, aged forty, in whom the disease began two years ago with great enlargement of the glands of the neck. Roentgen examination showed involvement of the 12th dorsal and first four lumbar vertebrae. The case shows that in the course of malignant granuloma there may be specific changes in the spinal column caused by the disease. The changes in the vertebrae look very much like those in metastases of tumors and in Gaucher's disease. The changes are chiefly those of osteoporosis and consist of disseminated foci of decalcification of bone tissue with breaking down of the bodies of the vertebrae, leaving the intervertebral discs intact. But there are also foci of condensation of bone tissue. The character of these changes is due to the fact that they do not originate in the joint cartilage, as do those of Pott's disease but in the reticulo-endothelial system and particularly the bone marrow.

Harvey, Joseph L. Ankylosis of joints. Case report. *Radiology*, June, 1928, x, 510–511.

An extreme case of ankylosis is described in a young man, aged thirty-five, in which roentgenograms showed clearly the extent of the condition. The patient had had chicken pox, measles and whooping cough with no sequelae, and was apparently normal at the age of twenty-two, but had suffered three attacks of what appeared to be rheumatism during the three years following. He entered the hospital complaining of shortness of breath, palpitation, swelling of ankles, headaches and high blood pressure. Heart and kidney disease accompanying ankylosis followed the attacks of arthritis. Except for the upper extremities, there was ankylosis of all the joints. Roentgenograms of various joints showed complete fusion of the bones, decalcification, with fine striae and absence of joint spaces and surfaces. Exact classification of the condition was not determined, but diagnosis of ossifying arthritis and arthritis deformans atrophica chronica, proliferative type, is suggested. Autopsy findings showed chronic passive congestion and amyloidosis of spleen, kidneys and adrenals. The cause of death was myocarditis. The roentgenograms illustrate clearly the extent of fusion of the bones and decalcification.

Hawley, George W., and Griswold, Arthur S. Larsen-Johansson's disease of the patella. *Surg., Gynec. & Obst.*, July, 1928, xlvii, 68–72.

In the authors' opinion, a clear parallelism exists between Larsen's and Schlatter's disease. In each instance there is anomalous bone formation—in the latter the beak-shaped tibial epiphysis, in the former, the accessory center of ossification at the apex of the patella. It seems natural to believe that a potential mechanical weakness exists at the lower end of the ligamentum patellae in the one case, and at the upper end in the other. These two lesions are regarded as not usually associated with sudden trauma, but rather the result of continued strain on the patellar ligament. Furthermore, the clinical signs, symptoms, roentgen findings, course, prognosis and treatment are so similar that the analogy appears complete.

The diagnosis is based essentially upon the finding of a definite circumscribed point of tenderness over the lower tip of the patella, and the detection by roentgenological examination of a separate center of ossification at this site. A case is reported which emphasizes the value of giving due recognition to the common

physical sign of a sharply defined point of localized tenderness and the necessity for careful investigation as to the cause of the tenderness.

HERZOG, F., and FIRNBACHER, E. Anomalies of the aorta and the esophagus. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, XXXV, 1236–1243.

A report is given of a case of right-sided high position of the aorta. Roentgenographically it was observed that the ascending aorta began its course from about the middle upper part of the heart shadow, progressing steeply upward and a little to the right, then bending sharply along the right main bronchus; with a short turn to the left it merged into the descending aorta, the latter curving widely to the right and crossing the vertebral column again to the left. As a result of this anomaly, the course of the esophagus presented two abnormal curvatures; the first was in the region of the aortic arch and directed toward the left, and the second, because of the position of the aorta in front of the vertebral column, curved forward over the aorta. These observations were incidental in the examination of a patient aged sixty-seven, who had suffered no symptoms from the above-described anomalies. The condition is assumed to be congenital.

HESS, GEORGE H. Pancreatic lithiasis. Report of case with autopsy findings. *Radiology*, April, 1928, x, 342–346.

No definite symptoms can be attributed to pancreatic lithiasis and very few authentic cases have been reported. In the present case, the gastrointestinal disturbances with periodic pain, can be explained by gall-bladder and appendix pathology, because after removal, the symptoms did not return. Roentgen findings plus hyperglycemia and glycosuria can be relied on for diagnosis. In the presence of gall-bladder pathology, it may not be discovered at operation. Even though the pancreas is apparently functionless, an individual may continue to live in good health. The proper use of insulin and regulation of diet and exercise will affect the duration of life, however. An excessive use of insulin may be even more dangerous than hyperglycemia.

The present report is that of a white male, aged forty, who was suffering from gastrointestinal disturbances. Physical examination was essentially negative except for slight tenderness upon deep pressure over the gall-bladder area. Forty-eight hour roentgenograms showed a rather long twisted appendix which was adherent, and in the gall-bladder area there were many small densities resembling biliary calculi. At operation, the gall-bladder was found to be enlarged, adherent and showed chronic inflammation, but no calculi. The appendix was found to be adherent, twisted and filled with concretions. Both were removed, following which the patient made an uneventful recovery. A roentgenogram made after recovery showed shadows over the gall-bladder area similar to those first observed, which were shown to be trailing across the upper abdomen, which were obsured previously by the barium meal. Four years later the patient died from complication of alcoholism and diabetes. At autopsy, it was found that the pancreas was firmly bound by adhesions and, on removal, weighed 190 grams. Roentgenograms of the excised organ showed innumerable calculi, dense fibrosis and a large cyst in the head of the pancreas. Pathological sections were also made. The pathologic diagnosis was pancreatic lithiasis, chronic pancreatitis, with destruction of parenchymatous tissue and cyst formation.

HIRSCH, I. SETH. On a foramen in the lower extremity of the humerus. *Radiology*, March, 1928, x, 199–208.

The author has made use of the roentgenogram in studying a foramen in the lower extremity of the humerus. Photographs of the humerus of man and the gorilla are first presented to show the different stages of perforation. The roentgenograms of the humerus of living subjects show this condition clearly, and the author suggests that it be looked for as a routine matter, not only for its clinical significance, but also for its anthropological interest. It is not found before the age of six years and is usually bilateral. It is more common in the female. Since it is an anatomical variation, it should not be misinterpreted.

HIRSCH, I. S., and TAYLOR, H. K. Gall and gall-bladder diagnosis. *Radiology*, July, 1928, xi, 37–44.

This is a critical review of the roentgenologic diagnosis of gall-bladder disease, giving in their order the enthusiasm for the different procedures and the interpretation of results made. Even the value of cholecystography is limited, but the authors agree that this test has increased the percentage of calculi detectable and for that reason is of much value in the treatment of early stages of gall-bladder disease.

HOESCH, K. Gall-bladder and duodenum. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1927, XXXV, 1190–1198.

Practically the same set of complications comprising duodenal stenosis, periduodenitic adhesions, spastic contractions or distortions

of the bulbus may be found in cholecystitis as in duodenal ulcer, and consequently the question of diagnosis is a complicated one. Cholecystography furnishes an important differentiating procedure in such cases. To determine the seat of primary disease the combined method of study, namely, cholecystography and serial roentgenography of the duodenum, offers a means of obtaining specific data which may clarify the above mentioned symptoms. The author has been able in a number of cases to obtain definite local diagnosis by means of this procedure.

In performing cholecystography, the author prefers the intravenous injection of tetraiodophenolphthalein salt. About 3 to 4 gm. of the dye, dissolved in 40 c.c. distilled water is injected late in the preceding evening. The first examination is made the next morning about ten to twelve hours later. The slow injection of the tetraiodo-salt causes practically no disturbances. If they occur, it is considered that a poor injection technique has been employed. The best gall-bladder pictures are obtained in the fourteen to sixteen hour period. Emphasis is laid upon the pathogenic importance of gall-bladder affections for changes in the duodenum. In all cases in which the ordinary examination of the gastrointestinal tract yields only a few indistinct direct or indirect signs, the combined method is particularly necessary to reach a correct diagnosis.

Kennon, Robert. Infective osteomyelitis. *Surg., Gynec. & Obst.*, July, 1928, xlvii, 44–52.

In the majority of cases of acute osteomyelitis during the first week, roentgenological examination is a waste of valuable time and may prejudice the patient's life. There is, however, no doubt that if at the end of forty-eight hours the case has developed a small local swelling, associated with pain and tenderness over the end of the bone, the roentgenologist—by examining the minute details of films of the limb taken from different positions—will be able to demonstrate by the slight roughening of the osseous surface, the exact position in which the central abscess makes its exit. Such information is clearly of decided value to the operator. If, on the other hand, marked roentgenological changes in the bone are evident within the first forty-eight hours after the discovery of the symptoms, the case is more probably one of tuberculous osteomyelitis.

Roentgenological examination affords more conclusive evidence when the case has been neglected or overlooked because sufficient time will then have elapsed for decalcification of the bone to be perceptible, and, of course, if the case is of the chronic type the roentgenologist's report is invaluable. The history of the case will serve to differentiate instances of decalcification of the bone due to hemorrhagic effusions or due to passive edema of a limb from an injury.

The foci of acute osteomyelitis are in the diaphyses of long bones; their positions and lines of extension to the periosteum are almost invariable. Maximum tenderness on deep pressure over the osseous focus is present and is of diagnostic importance in early stages prior to the development of the subperiosteal abscess which usually forms on the diaphyses near the epiphyseal line.

Surgical procedures should be directed to the points of maximum tenderness without delay in order to obviate extensions to the joints. Tuberculous infections appear to originate in osseous foci and to extend in a similar manner; for extremely early cases operative measures at the hands of experts appear logical.

Kirklin, B. R. The normal cholecystographic response. *Radiology*, July, 1928, xi, 34–36.

Of 251 cases showing normal cholecystograms, 204 were found on operation to be actually normal, thus giving an accuracy of diagnosis in this respect of 81 per cent. Lesions found in these 204 cases comprised mostly duodenal ulcer, pelvic lesions and chronic appendicitis. Positive cholecystographic diagnoses have a higher percentage of accuracy than negative diagnoses, as might be expected. Cholecystitis without stones may accompany a normal cholecystogram. Duodenal ulcer, chronic appendicitis, pelvic lesions and other diseases of abdominal origin do not affect the gall-bladder nearly as much as is usually expected and a normal cholecystogram in very many instances is obtained when these diseases are present.

Knipfer, A. The roentgen picture of horseshoe kidney. *Radiol. med.*, July, 1928, xv, 684–691.

A case of horseshoe kidney is described in which several roentgenologists had made mistakes in interpreting the site and nature of the lesion. It was a case of horseshoe kidney with atypical calculosis which was not diagnosed by palpation or pyelography but by simple roentgen examination. It is difficult to demonstrate on roentgen examination the bridge that unites the two kidneys, and the author says it is not necessary. He emphasizes the importance of the abnormal outline of the lower pole of the kidney which is always visible and has a very characteristic shape. It ends in a point and its inferior-lateral border has a much more oblique curve than normal, which

gives the tip the shape of an ox-horn directed toward the midline. The eye has a tendency to complete the two tips of the horns. Another reason why it is not necessary to see the bridge is that it is superimposed on the spinal column and can be palpated against the spine; the part that can be palpated corresponds to the part that is lacking on the roentgenogram because it is lost in the shadow of the vertebrae and it completes the horseshoe form of the kidney. Often at the point where the bridge joins the kidney there is a furrow which can be demonstrated roentgenologically. As the direction of horseshoe kidney is downward in front and upward behind it is easy to incline the tube so as to take the picture of the kidney along its longitudinal axis and get a more intense shadow. Pictures should be taken in dorsal and ventral decubitus and the dimensions of the different parts compared. This is a good method of detecting the rare cases in which horseshoe kidney is all or almost all on one side of the spinal column.

ROENTGEN AND RADIUM THERAPY

BELOT, J. Resistance to rays of skin epitheliomas. *J. de radiol. et d'électrol.*, Feb., 1928, xii, 91–94.

The author has treated about 7,000 cases of skin epitheliomas and has found that epitheliomas of the same histological type sometimes show very different degrees of malignancy. But there is no doubt that if a skin epithelioma is not cured by a first ray treatment it later becomes more resistant to the rays. This may be due to a "vaccination" of the cancer cells against the rays or to the fact that the resistance of the connective tissue is overcome by the first treatment so that it no longer has any capacity for reaction. He agrees with Roussy and Laborde that the cases should be divided into ones that have been correctly treated at first and ones that have been incorrectly treated by small repeated doses. The reason for the failure is different in the two groups.

Certain epitheliomas, particularly spinocellular ones, do not heal even after correct treatment. This may be due to the fact that they are of a particularly malignant type, or to the fact that the dose has been insufficient; the second cause is the more frequent one. In following the development of the technique of treating the skin epitheliomas it is seen that the dosage has increased progressively; as the dose has been increased the number of failures has decreased. Of course the dose cannot be increased to the point where it will destroy the normal cells around the tumor.

The changed resistance of the cancer to later treatments may also be due to two causes, either to the fact that the malignancy of the tumor has changed spontaneously or to the fact that its sensitiveness has been decreased by the preceding treatments; the author is inclined to the former theory though he cannot prove it. But he calls attention to the fact that almost all skin epitheliomas that become resistant to the rays have suppurated; he thinks that the secondary infection is one of the chief causes of the increased malignancy of skin epitheliomas and their increased resistance to the rays.

At any rate, an attempt should be made in treating these tumors to apply a large enough dose the first time to bring about cure; if the first treatment does not cure the method should be changed.

BIRKETT, G. E. Radium treatment in carcinoma of the mouth and tongue. *Lancet*, May 12, 1928, i, 953–959.

At the Manchester Radium Institute the author observed during one year, 127 cases of carcinoma of the mouth and tongue out of a total of 565 cases of malignant disease. At the end of the year, 16 per cent of the group were free from evidence of either local or metastatic disease. Most of the cases of carcinoma of the mouth and tongue were almost in the last stages of the disease. The improvement in the method of application of the radium has resulted in a higher percentage of primary cures in succeeding years. The essential feature of the improved technique is the employment of constant sources of radiation heavily filtered so as to provide homogeneous gamma radiation.

The reaction, if 0.4 to 0.5 mm. platinum filtration is used, is not severe, and is hardly noticed by the ordinary type of hospital patient. As a rule, by about the fourteenth day the treatment zone becomes coated with a deposit or adherent exudative membrane which is best compared with the late fibrinous deposit over the pleura of a patient dead of lobar pneumonia. It is adherent but is by no means a slough. It usually disappears in about four to six weeks after treatment when the indurated zones becomes softer, but probably three months elapse before the area treated becomes as supple and soft as the ordinary healthy tissues. Occasionally, probably owing to faulty distribution of needles, tissue necrosis occurs, is accompanied by severe pain, and the formation of a depressed ulcer covered by a

tough, adherent, green slough and extremely tender to the touch. There is a surrounding zone of induration and sometimes only experience can decide whether this induration is due to the persistence of the causal factor or to an inflammatory thickening. Profuse hemorrhage accompanied treatment in 2 instances but occasioned no anxiety. It was probably due to ulceration in the lingual artery.

The results of treatment of lesions in various sites of the tongue or mouth correspond roughly with the ability to retain the radium tubes, with the exception of the floor of the mouth where bone is often involved; this constitutes a bad prognostic feature. Eighty cases were treated during 1926, and of these 27.5 per cent are still free from local or metastatic evidence of disease. In 38.8 per cent the primary lesion resolved. In 36.3 per cent there has been no evidence of recurrence at the primary site. During 1927 seventy-four cases were treated. Of these, 35 per cent show no signs of local or metastatic disease. In 45.9 per cent the primary lesion resolved. Some of the cases will probably resolve later. It seems that by means of a fairly uniform technique or, at any rate, by the employment of one principle of irradiation—a small unit dose for a comparatively long period of time—it is apparently possible to cure a considerable number of patients suffering from what was clinically undoubted buccal carcinoma. In 43 per cent of these cases there was a positive histological diagnosis; in an additional 16.6 per cent there was a negative Wassermann reaction. The diagnosis was purely clinical in the remainder.

The author believes that in the treatment of the primary site, needles with an active length of 2.5 to 3 cm. would produce better results in the more advanced types of case. The results in the treatment of the lymphatic area are disappointing. Possibly prolonged external irradiation may be of help in the radiosensitive type met with at the base of the tongue. It is apparently difficult to obtain a sufficiently intense depth dose in the more resistant types without damaging the skin too severely. Seeing how much more difficult it is to deal with the lymphatic region than with the primary lesion, it is hard to conceive that visceral metastases could be treated successfully. They are relatively uncommon in this type of malignant disease and most frequent in the undifferentiated types.

Burnam, Curtis F. Radium in intra-oral cancer. *Radiology*, Nov., 1927, ix, 366–372.

Radium has a wide range of applicability in treating mouth cancer, no location being too remote or difficult. Since there is no primary mortality following such treatment, radium should be used more generally for this purpose. The effective treatment goes beyond the area of actual destruction and there is a chance of retardation in the deeper layers. The irradiation of epitheliomas is essentially a surgical procedure. Precautions must be made to prevent irradiation of the normal tissues, and yet highly destructive dosage must be applied to the cancerous growths. There seems to be a very definite lethal dose for these tumors, and this maximum is fatal to all types and grades. The growth power of tumors may be greatly reduced by dosage 30 per cent under the lethal dose. The roentgen ray may be considered only as a supplementary measure in the treatment of mouth cancers.

Cheval, Max. Treatment of cancer of the cervix uteri by irradiation. *Brit. M. J.*, March 31, 1928, i, 537.

In 1920 the author gave up using needles with weak filtration (0.5 mm. platinum) as their action was too caustic and consequently too local (1 cm. distance). Preference has been given to tubes filtered by 1.5 mm. platinum plus 0.1 mm. Al plus rubber plus gauze or cork. The distant action is greater and extends to a zone of 3 cm. about each tube. Subtotal hysterectomies by the abdominal route are performed, followed by implantation of needles in the cervical stump. Vaginal applications are also made. Some of the patients presented recurrence in the neighborhood of the parametrium. To prevent this, the radium drainage method was employed. By this method, tubes of radium are placed outside the parametrium in the neighborhood of the external portion of the broad ligament. Recently use has been made of 4 gm. radium element applied at a distance over large fields. The whole of the small pelvis is irradiated with an equal intensity.

The irradiation seems to effect cures of a better quality than surgery. Of all cases treated by radiation, 30 per cent are definitely cured. An improvement of this percentage should be obtained by the new method using large amounts of radium placed at a distance.

Duffy, James J. Cervical lymph nodes in intra-oral carcinoma. *Radiology*, Nov., 1927, ix, 373–379.

The author discusses 271 cases of lip carcinoma which were admitted for treatment, of which number 210 showed no malignant nodes throughout the period of observation; at least two years. Only a very small proportion showed cervical metastases. The reason for this the author attributes to the method of

treatment. Practically every patient was subjected to irradiation of lymphatic drainage areas, whether or not nodes were palpable. Radium was used, the dosage being at first 8,000 mc.-hr.; later this dosage was increased to 10,000 and 12,000 mc.-hr. For the past three or four years, both radium and the roentgen ray have been given and in practically full dosage. The source of the roentgen ray is the 200 kv. outfit.

Ewing, James. Some phases of intra-oral tumors, with special reference to treatment by radiation. *Radiology*, Nov., 1927, ix, 359–365.

Cancer of the tongue is best treated by interstitial irradiation. The disadvantages are that irradiation may dislodge tumor cells and lead to metastasis, and again adequate irradiation may cause diphtheritic inflammation. Heavy external irradiation should be the first step, since this may destroy some of the tumor cells and in this way minimize the possibility of metastasis. In cases of epithelioma of the alveolar ridge, surface irradiation may often be sufficient in very early cases of this type, but the treatment of deeper tumors should be done by some other method. The high susceptibility of epithelioma of the tonsil to external and superficial irradiation makes treatment of this condition relatively simple. Lymphosarcoma of the tonsil and larynx respond very readily to irradiation. Neuroepitheliomas of the superior nares, and carcinomas of the maxillary antrum are not so favorably affected by irradiation. The far-reaching effects from infected tumors are also noted; prevention of such infections constitutes an important problem in itself, since these cancerous growths are surrounded by the mouth flora and continually subject to direct infection.

Gask, G. E. Radium in the treatment of malignant disease. *Lancet*, Apr. 28, 1928, i, 843–847.

The author, a surgeon, has for some years held the position of an agnostic, not convinced of the benefits resulting from radium in the treatment of malignant disease. After close study of developments, he is now convinced that there is in radium a means of treating cancer which will prove of inestimable benefit.

Radium treatment of carcinoma of the cervix uteri has yielded some very remarkable and brilliant results. The technique which has been found successful is that of burying the radium needles in and around the tumor, with a space of approximately 0.5 cm. of tissue between each needle. These needles have been allowed to remain in position for about 144 hours. The benefits from this treatment, if they occur, are to be expected in the course of a few weeks. In many instances, the tumor formation which was obvious before irradiation disappeared, ulceration healed and hemorrhage ceased. It remains yet to be proved whether patients so treated will remain free from disease and for how long. It remains also to be proved whether the operable patients will live longer if treated with radium or if submitted to surgical removal of the whole uterus. In carcinoma of the breast, it has been found that though patients were in no sense cured, yet the action of radium on the primary tumor was marked and resulted in a definite shrinkage. It has been found that, generally speaking, better results are obtained when the breast tumor is subjected to small doses of radium over a long period. Of a series of 13 cases carefully observed, 4 have died of metastases in remote parts of the body, though all showed a shrinkage of the primary tumor. In the other 9, the results have been very good; their tumors have disappeared and they remain in good health. They have not had mutilating operations and they are much pleased with the results. Although they are free of signs and symptoms, it is not held that they are cured of their disease. Such results are good enough to justify the treatment of more patients in the same manner and the choice of patients who are not in the advanced stages of the disease and who would be usually fit subjects for surgical operation.

In the treatment of carcinoma of the upper air passages, radium may be a method which may supplant the old mutilating operations. The after-results seem to be far superior to those which have been obtained from operation. Surgical treatment of carcinoma of the tongue and the floor of the mouth has never given satisfactory results, whereas the effect of radium has, in many instances proved brilliant. It seems hard to believe that a proved epitheliomatous ulcer of the tongue will disappear, that the skin will heal and the tongue become mobile at the end of seventeen days after treatment with radium, yet such a case was observed by the author. The only thing at all comparable to this is the manner in which a gummatous ulcer will melt away and heal under antisyphilitic treatment. The treatment of the lymphatic area remains a difficulty which has yet to be overcome in the treatment of carcinoma of the tongue by radium, and it is possible that the right treatment may be to irradiate the primary growth in the tongue and then remove the lymphatic glands in the neck by block dissection.

HESS, GEORGE H. Possible developmental defects following over-radiation of thymus in early infancy. *Radiology*, Dec., 1927, ix, 506–509.

Too strong irradiation of the thymus in infants is very likely to cause a reduction in size up to 80 to 90 per cent. When such destruction of the thymus occurs, a very decided effect on the development follows. The author gives 2 case reports in which typical Mongolian idiocy followed roentgen treatment of the thymus in infants of seven and four months respectively. In each case there was marked improvement in symptoms, but after about two years the serious effects of over-irradiation was noted. Both infants were unable to walk or talk at the ages of two and a half and three years respectively. Because of this experience, the author suggests that the treatment be reduced to the following: 7 in. spark gap, 5 ma., 15 in. target skin distance, 1 mm. of aluminum, for 2 min., and only sufficient treatment to relieve the symptoms, using one area at a time. If one such treatment relieves cyanosis and difficult respiration, no other treatment should be given.

JUDD, E. STARR, and NEW, GORDON B. Surgery in cases of intraoral cancer. *Radiology*, Nov., 1927, ix, 380–387.

The authors agree with Simmons in that surgical operation is preferable to irradiation in the treatment of mouth cancer. There are many cases being reported of patients with inoperable mouth cancers following roentgen-ray or radium treatment which could have been removed surgically with good prognosis at the time the treatment was instituted. The surgical removal of glandbearing fascia has become the surest method for preventing glandular involvement secondary to cancer of the mouth. In addition, roentgen rays and radium should be used.

MACLEOD, J. M. H. Ringworm and its treatment. *Brit. M. J.*, Apr. 21, 1928, i, 656–659.

Ringworm being a local affection is not amenable to any form of internal treatment. The roentgen treatment is more rapid than any other method and has the advantage of being painless. In competent hands, it can be done with absolute safety. This treatment is, however, by no means easy, and necessitates not only an installation suitable for the purpose and a working knowledge of the dosage and application of the rays, but an intimate acquaintance of the disease and its management. Without this, it is a highly dangerous procedure and may lead to severe dermatitis and permanent baldness. The radiations act simply as a depilatory; they do not destroy the fungus. The procedure is to expose the whole of the scalp to a single pastille dose, which is sufficient to cause the hair to fall out without so injuring the papillae and follicles as to prevent regrowth. It is necessary to divide the scalp into five areas which are irradiated seriatim by the Kienböck-Adamson method. During the exposure it is essential that the head be kept still. Epilation is complete by about the twenty-first day; eight weeks later the hair begins to grow again as a thin down, and regrowth is complete in about six months. As a rule, it is advisable to irradiate the entire scalp, even when the disease appears to be confined to one or two small areas. The chief risk of the treatment is the danger of overexposure followed by dermatitis and incomplete restoration of hair. By the use of a specially designed couch in which children may be strapped, even infants of twelve months may be treated safely by the roentgen rays.

Before exposure to the radiations, the hair should be cut short with clippers and the scalp washed. Should any acute inflammatory disturbance be present, such as impetigo or irritation from previous treatment with parasiticides, especially iodine, it should be dealt with previous to exposure to the rays. After the exposure a cotton cap should be fitted to the scalp and worn continuously, and every day a 1 per cent ammoniated mercury ointment should be gently rubbed over the scalp. On the fourteenth day the scalp should be washed with a nonirritating soap and the washing repeated daily until the hair has fallen out. When the defluvium is complete, about the twenty-first day, the child ceases to be infectious. After-treatment of the scalp until the hair returns consists in washing and massaging it daily with almond oil or weak boric ointment to stimulate the circulation and so encourage the hair growth.

MOTTRAM, J. C. Observations on the combined action of colloidal lead and radiation on tumours. *Brit. M. J.*, Jan. 28, 1928, i, 132–133.

Experiments have been carried out to see whether a combination of colloidal lead and radiation would cause disappearance of tumors in doses such that the toxic effects of lead on the patient would be avoided, and likewise the destructive action of radiation on normal tissues. Mouse tumor T 63 was used and the results show that the combination of colloidal lead and radium radiation will cause a tumor to disappear, using doses which by themselves do not produce this effect but only result in

temporary retardation of growth. It has been suggested that this effect may be due to both treatments acting upon the blood vessels of the tumor and interfering with its blood supply. In the case of radiation, this action has been shown first to occur about four days after exposure. Since the best effects of the combined action are obtained with intervals of three or four days, it follows that lead must begin to act on the blood supply of the tumor about seven to eight days after inoculation, provided, of course, that lead acts in this manner. It has also been suggested that radiation has greater action after lead treatment on account of the secondary radiation arising from the lead deposited in the tumor. This might be due to the characteristic secondary radiation from the lead. The results support the view that this combination of treatment should be given a trial in the case of patients suffering from cancer.

Rose, B. T. Notes on the treatment of oral and rectal cancer by radium. *Brit. M. J.*, June 2, 1928, i, 936-937.

Twenty-nine cases of cancer of the mouth are considered. Of these 27 were in males and 2 in females. The average age was fifty-nine years, the youngest was forty-six and the oldest seventy. Biopsy was performed in 27 cases, the finding being squamous epithelioma. The remaining 2 cases not submitted to section were clinically unmistakable and proved fatal. Dental sepsis is regarded as being undoubtedly a predisposing factor in the oral carcinomas here studied. In the majority of cases radium needles were inserted into the primary growth. The needles were 5 mg. tubes screened with 0.5 mm. platinum. The number of needles varied with the size of the growth. In some cases where the floor of the mouth is involved, it is difficult to protect the mandible from necrosis. The needles were kept in position for forty-eight hours, in most cases. The average dose was 1,920 mg-hr. for the primary growth. In many cases a second and even a third dose was given. Where the glands were enlarged and operable a block dissection of the neck was undertaken and radium needles were implanted in the wound. In 20 cases the glandular fields were treated by irradiation alone, needles being imbedded in the tissues of the neck through a trocar. Ten to fifteen needles were used over a period of forty-eight to fifty-six hours. Most of the cases had two applications to the glands at intervals of three months, while a few had three or more.

Of the 29 patients treated and observed for two to three years, 10 died, 11 showed no improvement and 8 had improved. In 9 of the 21 patients who died or were not improved, the primary growth had been apparently checked and healed, but the glandular deposits had continued to progress. It is to be noted that all cases treated were past all surgical intervention, and it is probable that earlier cases would react much more favorably than the figures indicate. Small doses over a prolonged period of time are preferable to large doses acting for a short period. The 5 mg. tubes are probably too large a dose for very prolonged insertion. The best results are to be expected from growths of the tongue itself, especially those of the anterior two-thirds; epitheliomata of the floor of the mouth and the pharyngeal portions of the tongue are especially difficult to treat, owing to difficulty of access and also the danger of necrosis. The warty, exuberant type of epithelioma gives a better result than the ulcerative type, which unfortunately is the more common.

The number of cases of rectal cancer reported on is 26; 22 males and 4 females; the average age was fifty-seven; all were advanced and inoperable, in most cases there was extensive infiltration of surrounding structures, especially the bladder, prostate and perirectal cellular tissues. Biopsy in 23 cases showed the presence of adenocarcinoma; in the remaining 3 patients, the growth was inaccessible, but these were clinically typical carcinoma, and in none did any improvement occur under radium treatment. All the patients were advised to have a preliminary colostomy. Needles of 5 mg. and occasionally 10 mg. screened by 0.5 mm. platinum were used. In all cases needles were implanted deeply into the growth from the rectal surface in addition to implantation into the perirectal cellular tissues by puncture of the perineum and ano-coccygeal raphe with a trocar. Owing to the large mass of these advanced rectal growths, 15 or 25 mg. needles were required to give a sufficient cross-fire action. The rectum tolerates these large doses well if a preliminary colostomy has been performed, and the tubes are not placed too close together. It has been found advantageous to pack the bowel lumen with rubber tissue to keep the needles imbedded in the growth well apart. The average exposure was about 4,200 mg-hr.; the number of exposures varied with each case.

Of the 26 patients in this group, 13 are dead, and were not improved in any way, 8 are alive without improvement and 5 are definitely improved. Of the latter, 2 were irradiated twice, receiving a total of 9,600 and 8,900 mg-hr. respectively; 2 were irradiated three

times and received totals of 16,000 to 17,000 mg-hr. One was irradiated four times and given a total of 15,300 mg-hr.

Cancer of the rectum is a much less favorable field for radium therapy than cancer of the tongue. The reason for this is the difficulty of access and still more the great opportunity for an infection, which is almost inevitable. Further, it is difficult and probably impossible, to reach the upper part of the glandular field with any extension of the surgery of access, the glands along the inferior mesenteric artery being quite out of reach. For any satisfactory results, the growth must be early, low down and the glandular field but little involved.

ROUSSY, G., and LABORDE, SIMONE. The radiation resistance of skin epitheliomas previously irradiated. *J. de radiol. et d'électrol.*, Feb., 1928, xii, 83–90.

The radiosensitiveness of cancers decreases with successive irradiations. Pierre Delbet called this a vaccination, though it is only a question of local resistance of the cancer to a physical agent. The authors have made a study of 25 cases of skin epithelioma treated with roentgen rays or radium. In some of the cases the epithelioma was refractory, or semi-refractory to a first treatment that was apparently given correctly, and later treatments had no effect. In another group of cases, the technique of treatment had been incorrect; the doses had been insufficient and repeated too long. The resistance to the rays seemed to be more marked the longer the treatments were continued.

The authors think it probable that injury of the connective tissue stroma plays a part in this increased resistance, but that is probably not the only factor. But they do not think that in such cases it is necessary to give up radiotherapy entirely and resort to mutilating surgical operations. The technique of application of the rays should be changed, either by using radium when the first treatments have been with roentgen rays, by using unfiltered roentgen rays when the first treatments have been with radium or changing the method of application of the radium.

RUSS, S. The experimental basis of radium therapy in cancer. *Lancet*, May 5, 1928, i, 903–904.

If careful and detailed descriptions of any particular radium technique be recorded, the same treatment with identical dosage can be followed by others in any part of the world. When we remember the great difficulty of exact measurement of dosage when using roentgen-ray bulbs of varying output, this great advantage of radium is evident.

Radium seems to have a selective action on the tissues. The effect is not the same on all tissues and the reaction is often delayed for several weeks. The radiations are much more destructive on lymphocytes and some glandular structures than on many other normal cells of the body; apparently some of the least sensitive are muscle, cartilage and nerve cells. The question whether they have a greater destructive action on malignant tissues than on the normal tissues of the host can hardly be answered by a plain yes or no. No doubt in time we shall have accurate data which will make it possible to place the different normal tissues of the body and malignant tumors in the right order of vulnerability, and when this is possible on a quantitative basis, the question may be answered more certainly than it can now. Experimentally, it is not difficult to find a physical dose which will have a lethal action upon animal malignant cells, but this physical dose can be arrived at in a very large number of ways by variations in time and quantity and yet still remain a lethal dose. Which of these ways is the best to adopt when a malignant growth is to be treated *in situ* is not yet definitely known.

In treating cases of cancer with radium, unless one can visualize the range of effect with some accuracy, tracts of growth are apt to be left untreated; this is a vital point and it emphasizes the necessity of carefully planning the irradiation so that the whole of the involved region receives an effective dose. The radium should be distributed in as many foci as practicable rather than concentrated in one spot. The question as to which is the best kind of dose to use therapeutically can be answered only by trial. Experiment shows unmistakably that one cannot use very small intensities of radium and hope to get a lethal effect on malignant cells. There is a disquieting possibility that quiescent cancer cells may be brought into activity by weak doses of gamma rays, but at present we have no definite experimental evidence on the point. It has been proved clinically and experimentally that malignant growths given repeated sublethal doses of gamma rays often develop an increased resistance to the action of the rays. In fact, tumor cells after repeated irradiation have been found to withstand as much as two and a half times the normal lethal dose. Some evidence exists to show that under certain conditions substances may be extracted from an irradiated tumor which actually stimulate tumor growth, and in this rather disturbing

possibility some of the bad results of radium therapy may find an explanation.

The ionizing action of the radiation is, in all probability, the one which, when intensity is great enough, at any rate starts processes which lead eventually to the damage of cells. There may be a locally intense ionization to which the tissues are ordinarily quite unaccustomed.

Stevens, J. Thompson. Carcinoma of the cervix: treatment by a combination of roentgen rays, radium, and electrothermic coagulation. *Radiology*, Jan., 1928, x, 57–61.

Cancer of the cervix is of two kinds, squamous cell carcinoma and adenocarcinoma. These have been successfully treated by means of a combination of roentgen rays, radium and electrothermic coagulation. The author's method is as follows: Whenever possible, the treatment is begun with irradiation of the pelvic contents with roentgen rays, using not less than 200 kv. The time of exposure over each port, together with the number of ports necessary, is determined by measurements of the patient's pelvis and of the radiations by means of the iontoquantimeter. The dosage is 170 e units to the cervix and all the pelvic lymphatics draining the uterus and cervix. The erythema dose is 200 e units. The entire treatment is repeated in two weeks' time. After the second treatment, the disease upon or within the cervix is destroyed and removed by means of electrothermic coagulation. Radium in the form of needles is then buried deeply and evenly throughout the coagulated area and the cervical stump. If 5 mg. needles are used, they are placed 1 cm. apart, while if 10 mg. needles are used, they are placed 2 cm. apart. Then a radium capsule containing not less than 50 mg. is pushed through the cervix into the uterus and the vagina packed tightly with gauze. Four to eight weeks later, roentgen treatment with high voltage as already described is repeated. If possible, there should be a follow-up period of five years.

Waldbott, George L. Roentgen-ray treatment of the spleen in asthma and in related allergic diseases. *Arch. Int. Med.*, May, 1928, xli, 683–701.

Eighty-five patients with asthma and associated allergic conditions were treated with small doses of roentgen rays over the spleen. Twenty-two of 60 children became symptom-free as a result of the treatment, 16 were temporarily relieved, and 22 did not respond to the treatment. Three of 25 adults became symptom-free following the treatment, 9 were temporarily relieved, and 13 were not improved. This gives an average of 36 per cent failures amongst the children, and 52 per cent amongst the adults. The patients designated as "symptom-free" were under observation for a period of time varying between six months and more than three years.

Patients less than four years of age showed the best results; and the treatment in patients over thirty years of age was less effective. Patients afflicted simultaneously with tuberculosis and the chronic emphysematous type of asthma did not respond to the treatment. In cases of infantile eczema and hypertrophied thymus, the condition did not improve. The best results were seen among the patients with a beginning allergic condition manifested by allergic bronchitis. Better results were obtained among patients with asthma who were sensitive to bacteria than among those sensitive to food, pollen, and emanation. In some patients who improved, the positive skin tests became negative within the first week after roentgen treatment. As a rule, the number of eosinophiles increased immediately after the treatment and returned to normal subsequently. A relationship did not exist between the degree of eosinophilia preceding the treatment and the efficacy of the irradiation of the spleen.

Thirty-seven of a total of 169 exposures were followed by reactions characterized by vomiting, nausea, abdominal pain or an asthmatic attack from one to five days after the treatment. Better results were encountered amongst these patients. The roentgen treatment was administered by the technique of Groedel. The factors were: 5 ma., 88 kv., 10 inch skin target distance, 4 mm. Al, exposure for six minutes. As a rule, two treatments were administered with an intervening pause of two weeks. The number of treatments and intervals between treatments were, however, adjusted to the individual case. Before the treatment was instituted, the patients were carefully studied to gain as much insight into the individual condition as possible. Skin tests, eosinophile counts and roentgenograms of the chest were made as routine procedures.

The value of the treatment is evidenced by the results obtained in suitable cases. Warning is given against its indiscriminate use. It should be applied only in cases of allergy in which the patients do not respond to ordinary therapy.

Ward, Roy. Inoperable sarcomata treated with radium. *Brit. M. J.*, Jan. 28, 1928, i, 123–125.

The clinical data of a series of 30 cases of sarcomata treated at the London Radium Institute are briefly summarized. The treatment is best carried out by the use of gamma

radiation. Many sarcomata will disappear under the effect of gamma rays, the malignant cells being destroyed by doses which do not harm the surrounding tissues. Some sarcomata are more susceptible to the rays than others. In lymphosarcoma, too great an importance should not be attached to the rapid disappearance of the primary growth, and the patient should be kept under observation for some considerable time so that the presence of any metastases may be promptly dealt with. The same type of tumor in different parts of the body does not always react in the same way. Radium rays have only a local effect. Separate metastases may be treated, but widely disseminated recurrences, when present, will eventually gain the upper hand. There comes a time when tumors which have previously reacted well will no longer respond to radiation, even when there is no evidence of metastases. Relief of symptoms and prolongation of life are seen in most cases, and some patients remain in good health for long periods, the growth becoming shrunken and fibrosed.

The radium treatment must be vigorous, both needles and surface applicators should be employed with a large quantity of radium. It is best to give a maximum dose at the first exposure. The applicators used by the author were of two strengths, containing either 1.25 or 2.50 mg. radium element per square centimeter. The applicators are disposed in such fashion as to obtain a cross-firing in all parts of the growth. All external applicators should be screened with 2 mm. lead or its equivalent and covered with rubber. The needles used contain 1, 2.5, 7.5, 10 or 25 mg. radium element, their lengths varying from 1.2 to 4 cm., and the wall of the needle varying from 0.3 to 0.5 mm. platinum or 1.0 mm. silver. Recently needles with a wall of 0.4 mm. monel metal have also been used. The action of large doses of radium radiation is to produce progressive degeneration. The principle underlying the treatment is to give a large dose for a comparatively short time, seldom longer than forty-eight hours. Tissues subjected to radium rays are very susceptible to bacterial invasion and every aseptic precaution should be taken when introducing needles into any tumors.

MISCELLANEOUS

Coblentz, W. W. Methods of measuring ultra-violet radiation. *Radiology*, Feb., 1928, x, 116–121.

The author has given a general discussion of methods of measuring ultraviolet radiation. He points out, first, the need for experience in a physical laboratory where specialists are familiar with radiometry, if the worker is to be able accurately to engage in application of thermal radiation. The various difficulties are noted, especially the proper functioning of the radiometer, the sudden unsteadiness of the galvanometer due to high frequency radio waves, etc. These difficulties are being overcome by the development of steady burning sources of intense ultraviolet radiation, suitable radiometers and suitable spectrometers. If the problem is biological, involving radiation of animal or some organic matter, radiation from the carbon or mercury vapor arc in quartz may be used. The leading physicists in Europe use the quartz mercury vapor lamp because it is convenient, easy to operate, steady-burning, and powerful in the emission of conveniently distributed lines at the approximate wave lengths 254, 267, 280, 289, 297, 302, 313, 344, 365, 405, 436, 547 and 579 millimicrons. With such a powerful source of ultraviolet radiation, it is possible to make measurements with a precision of 1 to 2 parts in 1,000. The author then takes up the technique used and recommended by various workers in this field, giving a review of the literature in doing so, and in describing the technique most commonly used at the present time, tries to explain the procedures as simply as possible.

Durham, Herbert A., and Outland, Tom A. Blood calcium and phosphorus in Perthes' disease; a new conception of the etiology. *J. Bone & Joint Surg.*, April, 1928, x, 301–306.

While changes in the calcium salt content of the areas involved in Perthes' disease and allied disorders seem to be a constant finding, there is apparently no data regarding the blood calcium and phosphorus in these conditions.The apparent neglect of this phase of the subject may possibly be due to the tendency to regard these diseases as strictly local ones. If one of the three current theories (traumatic, congenital, infectious) is accepted, it would hardly be expected that changes in the blood chemistry would occur. However, the question of the etiology of these disorders is by no means a closed one. During the past six months, the authors examined six cases of Perthes' disease and one each of Sever's apophysitis and Schlatter-Osgood's disease. The findings have been strikingly constant. In each case there has been a marked lowering of the serum phosphorus (1.50 to 2.01 mg. per 100 c.c. serum). In 5 cases the serum calcium was also lowered (average 7.41 mg. per 100 c.c. serum). Three cases of Perthes' disease showed a normal serum calcium. In every case the calcium-phosphorus product was considerably below the low normal limit of 35, the average being 15.40. It is

therefore concluded that Perthes' disease is characterized by a diminution of the serum calcium or phosphorus or both. The pathology is very similar to that of rickets and osteomalacia. These three conditions may be related etiologically.

Fox, Herbert. Polymorphonuclear neutrophils in the blood in lymphadenopathies: Their relation to classification and radiation treatment. *Arch. Path. & Lab. Med.*, Feb., 1928, v, 267–281.

From the evidence reported, the leucemic group is composed of true chronic lymphatic leucemia, sublymphemic leucemia and leucosarcoma in that they have, with lymphocytosis, a low number of neutrophils that are very susceptible to radiation treatment. In aleucemia lymphadenosis the percentages and numbers of neutrophils and lymphocytes tend to approach normal with relative insusceptibility to radiation. The cases have a tendency to osseous involvement which was not attended by polynucleosis in 2 cases reported by the author, and therefore suggest myeloma which is not characterized by a peculiar blood picture. This group of adenoses somewhat resemble lymphosarcoma in hematology. The tendency to final malignant stages in adenoses, as evidenced by the bony tumors, increases the resemblance. The neutrophils in lymphosarcoma do not decrease consistently under irradiation.

Hodgkin's disease is marked by a polynucleosis which is indifferent to irradiation except in the malignant and febrile cases in which these cells are variable. In the author's cases of reticulum cell sarcoma and endothelioma the neutrophils were unaffected by radiation and of no definite numbers.

From these figures one can deduce that there is a leucemic group, true chronic leucemia, sublymphemic leucemia and leucosarcoma, and a sarcoma group, aleucemic lymphadenosis and lymphosarcoma, with distinct neutrophil picture and reaction to radiation. These are separate from Hodgkin's disease which varies with its type, and from endothelioma and nonlymphoid sarcoma. These features, if corroborated, will with a biopsy, somewhat simplify the classification of a given case.

Fries, E. F. B. Ångström in English. *Science*, June 29, 1928, lxvii, 652.

To render the ō sound of the Swedish Å with an E as is done in "engstrom units" in recent publications is incorrect and possibly overdoing the effort toward simplification. *Ongstrum* is in English the nearest phonetic rendering of the physicist's name (cf. Webster's New International Dictionary).

Garcia, F. H. Ultraviolet rays and Fahraeus' reaction. *J. de radiol. et d'électrol.*, Jan., 1928, xii, 20–21.

Among the properties of ultraviolet rays is that of discharging bodies that are negative electrically. The authors made use of this property to study the mechanism of Fahraeus' reaction, or the sedimentation of the red blood corpuscles. There are two theories in regard to this reaction: the first, the electric or cellular theory which holds that it is due chiefly to the red cells, and the second the plasmatic or chemical theory which holds that it is brought about chiefly by the plasma. It is known that the electrical charge of the red cells is negative. If the electrical theory is true, anything that would lower the potential of the red cells would cause increased rapidity of sedimentation, but chemical bodies which change the composition of the plasma could not give a definite proof of this theory as they are only applicable to the pure plasmatic theory. The authors used the discharging property of the ultraviolet rays, which is called the Hertz-Hallwachs effect, to test the theory. They found that the action of ultraviolet rays greatly hastened the sedimentation of the erythrocytes as compared with that of the control tube not subjected to the rays. Irradiation of citrated plasma had no effect on the rapidity of sedimentation of the red cells.

The Hertz-Hallwachs effect of the ultraviolet rays shows that Farhaeus' reaction is an electrical one. As the electrical variations in the red cells are due to chemical changes in the plasma, the author concludes that Fahraeus' reaction is a reaction of an electrical nature between the plasma and cells.

Graham, Ralph S. A study of the circulation in the normal and pathologic kidney with roentgenographic visualization of the arterial tree, including the glomeruli. *Am. J. Path.*, Jan., 1928, iv, 17–32.

The injection of the renal vessels with a radiopaque suspension and the subsequent roentgenography of the kidney have proved a simple, easily accomplished procedure, readily adaptable to the necropsy room as a means of reconstruction of the arterial tree including the glomeruli. This method does not interfere with the usual methods of gross and microscopic examination. Roentgenographic results check accurately with the accepted anatomic conception of the arterial tree. In the normal kidney the vessels show: (1) a slender, gradually

decreasing caliber of the lumen; (2) branching at an acute angle except at the primary division of the renal artery; (3) interlobar and arcuate arteries with gradual curves and arches like a spreading elm tree; (4) interlobular arteries which are slender, delicate, closely set and almost parallel, giving a thick uniform cortex; (5) glomeruli that are very fine and numerous, grouped evenly around the interlobular arteries, giving an appearance stereoscopically of slightly cone-shaped columns with the interlobular artery in the center and their bases toward the periphery of the cortex.

Severe arteriosclerosis is marked by; (1) an uneven caliber of vessels with dilatations and constrictions; (2) a branching angle which approaches a right angle; (3) interlobar and arcuate arteries which are wider, club-like and do not taper gradually. Their curves are abrupt and angular; (4) interlobar arteries which are fewer, shorter, tortuous and do not run so perpendicularly to the cortex; (5) glomeruli that are larger, decreased in number and clumped around areas of best vascular supply; (6) with contraction of the kidney, the cortex thins and the entire vascular tree appears drawn out from the hilum, and the picture of the arterial tree, as a whole, suggests a gnarled oak rather than a graceful elm; (7) milder degrees of sclerosis are found first in the periphery, and extend further toward the hilum as the changes become more marked.

The vascular changes in syphilis, when present, are of the same appearance as those of arteriosclerosis. Examination by the injection method is of definite value in the study of thrombosis of vessels and infarcts. A comparison of the roentgenographic appearance of the arterial tree with urea nitrogen retention in the blood has failed to show a direct relationship between moderate arteriosclerosis *per se* and impaired renal function.

Acute nephritis, acute degenerative parenchymatous changes in the kidney tissue and passive congestion have never interfered with the injection procedure nor have they given a distinctive picture on the roentgenograms.

Griffith, Harry D., and Taylor, John S. The scientific basis of phototherapy. *Radiology*, Feb., 1928, x, 93–115.

The authors give a summary of the literature on phototherapy. They take up the nature and characteristics of radiation, wave length, intensity, the effect of certain wave lengths, etc. The chemical and biological actions of light, both destructive in the killing of bacteria, protozoa, etc., and also the beneficial effects from its uses in the treatment of rickets, tuberculosis, acute infectious diseases, etc. The paper represents a review of the present status of the use of radiation and phototherapy and also a discussion of the scientific basis on which their value rests.

Hartman, F. W., Bolliger, Adolph, Doub, H. P., and Smith, F. Janney. Heart lesions produced by the deep x-ray. *Johns Hopkins Hosp. Bull.*, 1927, xli, 36–61.

The effect of carefully measured roentgen irradiation upon the heart of sheep and a dog was studied clinically and pathologically. If the dosage is sufficient either in a single massive or in often repeated smaller applications, certain characteristic pathological changes are brought about in the heart. The gross changes are as follows: (*a*) hydropericardium; (*b*) hemorrhagic infiltration of the right auricle, especially of the right auricular appendage; (*c*) more rarely, after heavy dosage has been projected through the side there is thickening and hyaline degeneration of the epicardium with hemorrhagic infiltration of the ventricular walls; (*d*) at autopsy these animals show passive congestion of the viscera. Certain characteristic microscopic changes in the heart have also been noted: (*a*) in the auricular myocardium; (*b*) in the ventricular myocardium, and (*c*) in the His bundle of the sheep. These microscopic myocardial changes vary with the acuteness or chronicity of the lesions produced.

Irradiation was given with a modern water-cooled tube, delivering 200 kv., 30 ma., 50 cm. skin distance, 1 mm. Cu plus 1 mm. Al. An exposure of fifteen minutes represents approximately one human erythema dose. One series of experiment animals included 13 dogs and 5 sheep irradiated over the anterior thoracic wall through an area 7×9 cm. and 10×12 cm. respectively. Another group of 8 dogs was treated through a large area 15×15 cm., covering almost the entire anterior thoracic wall including the liver area, care being taken to protect only the stomach and intestines. A third group of animals consisted of 3 exposed through the right chest wall, with a window 7×9 cm. The dosage for the sheep ranged from 120 to 280 minutes, and for the dogs from 75 to 280 minutes.

Records are presented of patients who were given relatively large doses of deep roentgen rays over the cardiac area as a therapeutic measure for mediastinal or lung tumors, and who later came to autopsy. Microscopical sections of the myocardium from these patients show changes which are comparable to those found in the experimental animal following

exposure to roentgen rays. However, terminal infection and age of patient may have had a bearing on these findings.

Electrocardiographic records made from the various dogs used in the experiments showed a variety of deviations from the normal. The more noteworthy changes were: (*a*) inversion of T in leads I and II, and frequently in III as well. Certain abnormal forms of T were also noted; (*b*) paroxysmal tachycardia; (*c*) auricular flutter was recorded in 4 animals; (*d*) auricular fibrillation was recorded once; (*e*) slight prolongation of the P-R interval; (*f*) diminished QRS voltage.

There therefore seems to be ample experimental evidence that injury to the heart results from the direction of deep roentgen rays over it in sufficient dosage.

HODGES, FRED J. The roentgenographic measurement of cardiac output in man. *Radiology*, Feb., 1928, x, 122–125.

The author describes a method by means of which a fairly accurate measure of the cardiac output can be obtained. The apparatus consists of a powerful roentgen-ray generator and tube, a quick-action vertical plate shifter, two circuit breakers for timing, a string galvanometer for recording instant of exposure and a photo-electric amplifier. Seventeen cases were studied in an effort to determine the cardiac output at rest, and results were obtained which compare favorably with those reported by other observers. The average output obtained by this method of measuring is as follows: 5 liters per minute, 94.3 c.c. per minute per kilo of body weight, 73.4 c.c. per beat. A detailed description of the apparatus and set-up is given.

JACOBSON, VICTOR C., and WADDELL, KENNETH C. Effects of high-voltage cathode rays on the skin of the rat. *Arch. Path. & Lab. Med.*, Feb., 1928, v, 195–222.

A study was made on the biological action of cathode rays on the skin of the white rat, the new Coolidge tube, a modification of the Lenard tube, being used. This tube permits observation of the effects of the cathode rays in the air outside the tube. The factors were 100, 200 and 350 kv., 1 ma.; an area about 2.5 cm. in diameter on the abdominal skin being exposed to the rays at a distance of 2.5 cm. from the window of the tube. Thirty-six rats were used in these experiments, different groups being exposed to the rays one-tenth of a second and six seconds daily for fourteen days, and in single exposures of six, eight, ten, thirty and sixty seconds respectively. The intensity of the reaction of the skin varied according to the voltage and the length of exposure to the rays.

During the actual irradiation, the animal would exhibit a generalized muscular spasm, but otherwise did not show any systemic reaction either during the exposure or afterward, except such as might be attributed to absorption from the slough. The macroscopic changes seen were, first, an immediate change in the color of the white hair to yellow. When the hair had been previously removed a pronounced redness and edema of the skin occurred. After forty-eight hours the skin gradually became leathery and shrunken. It desquamated and an area of necrosis developed on the site of exposure, the ulcer never extending in depth farther than the first muscle layer. A thick crust formed but healing was sluggish; in only one rat was epithelial repair far advanced after fourteen days.

The most characteristic lesion in the skin is a fusing of the collagen fibers of the corium, and necrosis of the epithelium of the skin and hair follicles. Chemical changes produce marked alterations in the staining properties of the irradiated tissues. Vascular injury is less severe and is most in evidence after the hyaline fusion of the collagen appears. Separation of the zone of necrotic skin and collagen is accomplished by the digestive action of leucocytes. Epithelial repair takes place from the periphery of the wound and at a slow rate.

The depth of penetration of the primary cathode rays as measured by the thickness of the zone of fused collagen in the photographs varied from 0.07 to 0.22 mm.; but allowing for shrinkage of the tissue, the penetration is probably twice that depth. As the cathode rays produce hyaline fusion of the collagen of the corium and since the characteristic lesion of roentgen-ray injury is a similar collagen degeneration, the evidence seems conclusive that the biological effects heretofore attributed to roentgen rays are not due to roentgen rays, but to the cathode rays which they produce in the tissues.

LATTÉS, J. S., and LACASSAGNE, A. Elimination of polonium injected into the organism. *J. de radiol. et d'électrol.*, Jan., 1928, xii, 16–19.

The authors studied the elimination of polonium when it is injected alone and when it is injected in association with other metals. When it is injected alone, it is eliminated rapidly in the urine and feces; but if it is injected in association with other metals, it is eliminated slowly; at the end of a few days a practically constant elimination is established that continues until the death of the animal. The local injection of polonium

associated with iron or bismuth has the advantage of assuring a slow and prolonged action of the radioactive body and of lessening its toxicity.

MATTICK, WALTER L., and BUCHWALD, KENNETH. A clinical study of the effect of radiation on blood cholesterol in malignant disease. *J. Cancer Research*, 1927, xi, 86–94.

A study was made on 36 presumably malignant cases treated by high power roentgen rays, radium, or a combination of the two. Blood was sampled at least five hours after a light breakfast. In cases where it was possible, the blood was sampled after an all-night fast. Before irradiation the whole blood cholesterol averaged 158.1 mg. per 100 c.c. as compared with an average of 118.1 mg. per 100 c.c. after irradiation. All received high power roentgen-ray treatment except 3, one of which had radium pack, and the other 2 only radium seeds or tubes. Ninety-five per cent of the cases studied showed this drop in the blood cholesterol content, while 2 patients (5 per cent) failed to show this reaction; one was developing a septic pelvic phlebitis and the other was a far-advanced, recurrent case of breast cancer. Only 12 of the series showed symptoms of radiation sickness, all mild. No relation could be detected between radiation sickness or the amount of radiation and the extent of the drop of the cholesterol content of the blood. The decrease in cholesterol was not sustained, but the cholesterol tended to rise again to original levels after varying periods of time and in the face of repeated irradiations. No difference could be noted between malignant and non-malignant cases in the tendency for cholesterol to decrease after irradiation.

The cholesterol content of the whole blood in 40 cases of malignancy averaged 159.5 mg. per 100 c.c., thus not differing essentially from the content in healthy individuals.

MEYER, WILLIAM H., and GLASSER, OTTO. Further studies on the influence of radiation quality on the erythema dose measured in physical units. *Radiology*, April, 1927, viii, 311–316.

The authors have extended their studies of units of erythema doses and in this paper, in addition to correlating the ionization current, measured in electrostatic R units with reactions on the human skin, they have observed the influence of backscattering from the patient upon the erythema doses measured in the same way. Nine different radiation qualities were used, starting with a roentgen-ray beam giving a half-value layer with somewhat under 0.75 mm. of aluminum, produced with about 45 peak kv., unfiltered, and going as high as 215 kv. strongly filtered, giving a beam of half-value layer of over 14 mm. of aluminum. The authors confirmed their previous finding that the number of electrostatic R units per erythema decreases with decreasing penetration of the rays. Extending their observations to softer rays, they found that beyond a certain point, which occurs around quality C, the number of R units per erythema again increases rapidly. Tables and curves are given to illustrate these phenomena from which the following conclusion can be drawn: measuring by ionization in air and using large portals of entry, the same number of ionization units will not result in the same skin reaction when rays of varying qualities are employed. It was also found that for many of the radiation qualities used for therapeutic purposes, the number of electrostatic R units per erythema as measured without backscattering divided by the half-value layer in water is within ± 5 per cent a constant. The average of this constant is 235 for the electrostatic R units. The value of this relation $R/h = 235$ is that if the half-value layer in water of any roentgen-ray beam is known, its product with 235 will furnish the number of R units for that special radiation quality which is necessary to produce an erythema reaction of known degree on the human skin. The curve correlating the erythema doses in electrostatic R units with various radiation qualities reaches a minimum at about a roentgen-ray quality showing a half-value in 2 mm. of aluminum and ascends towards the harder as well as the softer ray side.